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New Rate Advance Petition

AS might have been expected under the extraordinary circumstances, the Eastern railroads have petitioned for a modification of the order denying them the 5 per cent advance they had requested. The new set of facts, without which a reopening of the case would not be possible, is furnished by the war. Those who are concerned for the financial well-being of the country as a whole earnestly hope for the success of the petition.

Civic Foresight

AMERICAN engineers interested in transportation matters have followed closely in recent years the waterway and harbor developments going on in Canada. The Montreal port works are well known on this side of the border, and recently the Welland Canal improvement has attracted much attention. For foresight and comprehensiveness, however, the harbor works now under way in Toronto compare favorably with these other developments, and can be truly said to stand in the forefront of all harbor works projected or executed in North America. Other cities have developed immense docking systems; some few have tried to combine intelligent city planning with the commercial development. In Toronto commercial and recreational development have both been provided for on a very liberal scale. Three features stand out strongly: First, an extensive industrial area providing unsurpassed sites and facilities for manufacturing plants and warehouses; second, a dock system planned on such broad lines as to be able to take care of any possible development of commerce for at least half a century to come, and, thirdly, a boulevard and parking scheme extending over a length of 14 miles. Justification for this extensive program is found not only in the rapid growth of the city itself and in the recent development of its commerce, but also in the coming increased importance of the Welland Canal, on which the Canadian Government is spending $50,000,000. The work deserves the careful study not only of all harbor engineers, but of all who are interested in civic advancement through proper provision for commercial and shipping interests, and health-giving improvements for the citizens.

Problems Little Appreciated

WHEN a large railway passenger station is built pages are devoted to descriptions of the building, but the track facilities are usually dismissed with a bare statement of the number of tracks and the length and width of platforms. Tracks are deemed a minor consideration, and those outside the trainshed do not even get into the story. This is not unnatural, as the building is the spectacular part of the improvement, and neither the architect nor the manipulator of falsework and erecting cranes has a chance to display his skill in the design and placing of frogs and switches. Give the operating official his choice, however, between a monumental headhouse with outgrown trackage and an adequate track layout with indifferent waiting rooms and ticket offices, and he would unquestionably choose the latter. Nor is it true that when the number and length of platform tracks have been decided upon it is only necessary to lay and connect them. While precedent and standard practice are able assistants in structural and architectural design, the trackage of any large terminal is a problem unto itself and its designer must couple ingenuity with knowledge of railroad operation in general and local conditions in particular. All of which leads up to the article on page 316, describing the amplification of the track layout at the reconstructed Jersey City terminal of the Central Railroad of New Jersey. It is unnecessary to repeat here the special problems to be overcome. The article indicates how careful was the planning, how painstaking the study. For the benefit of those unversed in such work it is not amiss to state that the solution of such problems is one of the most fascinating and least appreciated branches of railroad civil engineering. Too many young engineers, failing at the start to perceive the importance and complexity of track work, dismiss it as trifling and turn to the crowded fields of structural and architectural design.

Plight of the Railroads

LAST week's meeting between President Wilson and a body of railroad presidents was a sign of the possibility of a better understanding between the Government and the carriers. It may also have an immediate good effect in enabling the railroads to meet a situation which menaces the country as a whole. The roads had troubles enough before the war struck them. Now they need a relief from more "regulation" and more burdens, at least until they find a way to bear the ills they have, the most conspicuous of which is the decline of $120,000,000 in net operating income in the year ended June 30 last. To these ills are now added the closing of ordinary sources of capital supply, probably for many years, and the great increase in the cost of refunding or renewing existing obligations. More than half a billion of railway obligations will mature in the next fifteen months, and if New York City has to pay 6 per cent for money it is no wonder that the railroads are frightened to think what they will have to pay.

In effect, what the railroads ask is that the Interstate Commerce Commission and Congress, and the legislatures and railroad commissions of forty-eight States let up on them for a while. President Wilson says in the letter he has written in reply to this plea that he thinks this is a reasonable suggestion. This is said as plainly as a President could say anything of the kind, and not the least significant sentence in this letter is this: "Undoubtedly men, both in and out of official position, will appreciate what is involved and lend their aid heartily wherever it is possible for them to lend it." This is as plain an intimation as an executive could give to administrative and legislative bodies that it is time to give the railroads a rest; to enable them in "legitimate" ways to obtain more revenue, and to impose no more expenses upon them until they can find a way to pay those that they already have.

An examination of some hundreds of editorial comments on the 5-per cent rate increase decision shows an almost unanimous opinion that the railroads have been getting the worst of it from the commerce commission in a way injuriously to affect the country as a whole. President Wilson's reply to the railroad men, even more than their own statement, will crystallize and strengthen this opinion, and so work toward better days for the carriers. This is a good thing for everybody, for we cannot have even a bearable general industrial and financial condition unless we have solvent and progressive transportation agencies. Investors will owe President Wilson a greater debt of gratitude than they will ever be aware of if he has enabled the railroads to keep clear of the financial rocks on which they were surely drifting and of which they are by no means clear.

The Trade Commission

BOTH houses have now agreed upon the trade commission bill, and before this is published the President will doubtless have signed the measure that establishes an entirely new piece of industrial machinery. The Federal Trade Commission of five members, with greatly expanded powers, will take over the work of the Bureau of Corporations; it will assist the Department of Justice and the courts in dealing with the economic and business problems that are involved in anti-trust suits and dissolution decrees; it can take testimony and its rulings are enforceable by circuit courts, which, however, will only review matters of law, the commission's findings as to facts being conclusive.

The commission has the power to conduct fishing expeditions of its own in industrial waters, without waiting for instructions from the courts or the initiative of outsiders. Instead of going to the Department of Justice for guidance or waiting until haled into court to find out whether or not he is within the law, the big business man will soon have a refuge in time of doubt. That is, he will have such a refuge, and probably a warning more friendly than the complaint in a lawsuit, if the commission is so constituted and conducted that it becomes a body co-operating with business, rather than an inquisition and an instrumentality which conceives it to be its duty to harass and restrict.

The fault legitimately to be found with the Interstate Commerce Commission is that, notably in the 5-per cent freight increase case, it does not handle its work in a business-like way. Half of the men who compose the commission are not big enough for their jobs. Considering the magnitude of the work to be done, perhaps this is to be expected. The trade commission has as big a work to perform as that of the commerce commission. If it should undertake anything like the same regulation of interstate business that is exercised by the commerce commission over the railroads, or if it grows in scope as rapidly as that commission has grown, the trade commission will have a task even larger than the older body.

All of which are reasons why men appointed on the trade commission should be able enough for the responsibilities they assume. The President has said that he does not intend to make these appointments until December. He can make no better Christmas present to the business men of the United States than a body of commissioners big enough to tell big business how to conduct its affairs. It is not unfair to say of the Interstate Commerce Commission that its members do not measure up to their jobs as well as do the justices of the Supreme Court. Fitness has, with rare exception, been the only consideration in making appointments to that court. The same rule must apply to appointments to the trade commission if it is to do its work with credit to the Government and to become a useful and valuable agency in business.

Forward Step in Municipal Finance

DUE credit has been paid by the press of the country to the courage, ability and resourcefulness of the New York bankers, headed by J. P. Morgan & Company and Kuhn, Loeb & Company, in arranging for the funds needed by New York City in meetings its obligations, largely held in Europe, which shortly become due. In raising $100,000,000 in gold, thus preventing the defaulting of the metropolis, they have rendered a National service. Only those who have worked night and day, persuading the directorates of one hundred and forty banks to participate, know how arduous was the task.

Their achievement, however, should not be allowed to detract attention from the great step, simultaneously announced, of placing the city on a "pay as you go" basis. The knell of the long-term bond, of the saddling of present benefits on future generations, has been sounded.

It has been resolved by the Board of Estimate and Apportionment that beginning with 1918 all permanent improvements, except of the revenue-producing class, shall be paid for out of the tax levy. Meanwhile a graduated plan is to be put into effect. Improvements which produce revenue—rapid transit lines, the water supply system and dock developments—are still to be financed by 50-year bonds.

In detail the transition period is to be cared for as follows: The improvements authorized during 1915 are to be financed to the extent of 75 per cent by the issuance of 15-year corporate stock, to be retired in fifteen annual installments. The remaining 25 per cent is to be raised by one-year bonds payable from the next annual tax budget. The improvements authorized in 1916 will be financed half by 15-year stock and half by 1-year bonds, while in 1917 the percentages will be 25 per cent and 75 per cent, respectively.

This announcement marks the culmination of plans on which the present controller has been working for some years. The first step was to pay for paving work with 10-year rather than 50-year bonds. Theoretically a bond-life equal to that of the improvement which it represents is justifiable. From this standpoint New York may now be considered to have gone from one extreme to the other. Whereas all of its permanent improvements in the past have been represented by 50-year bonds, now no bonds will be allowed, except for revenue-producing improvements. The one-year bond to be used is merely a means of tiding over until the taxes become available.

The new plan will have two very salutary effects. First, it will increase the city's credit—a consideration even in the strongest position of the city, for large amounts must always be raised by bonds for the revenue-producing improvements. Secondly, it will have a tendency to make both citizens and officials scan most carefully any proposed work. Heretofore, money obligations of the city were too far removed from the individual pocketbook. The future generation carried the heaviest part of the load. Now any large enterprise will directly affect the tax levy. Every taxpayer in the city will be hit, and those who desire to be returned to power will be chary of antagonizing the voters. Only when a plan can readily be defended will it be adopted.

The new move, then, is to be heartily commended, and the administration responsible for it is to be congratulated on its courage. The plan deserves widespread imitation.

More Light on a Complex Subject—Drainage Area Yields

ONE of the notable events of the recent convention of the New England Waterworks Association was the presentation of a report on stream flow and storage by a committee composed of many of the foremost hydraulic engineers of New England, with Frederic P. Stearns as chairman. Years ago when fewer hydraulic data had been collected engineers thought they knew quite definitely how much storage capacity must be provided to develop a water supply for municipal use. Two streams, the Sudbury River supplying Boston, and the Croton River supplying New York, had been gaged, and the results were studied to see how much storage was required to hold the flood flows and make them available for use when needed. The fact that storage quantities deduced from the records of these two important streams gave results closely in accord with each other served to encourage a natural but mistaken belief that the storages so found were quite definitely fixed and could be used in making estimates not only for the two streams from which they were obtained, but also for many other streams similar, or supposed to be similar, to them in their flows. Tables and diagrams, accurate to several decimal places, permitted ready application to new problems.

This was a case where a little knowledge was dangerous, and doubly so, for it touched one of the prime necessities of a city's life —its water supply. As more data have been accumulated by accurate gagings of other streams, it has become apparent that it was a mere coincidence that the Sudbury and Croton records of a certain period indicated the same relative storages for development, and since then those records have seemed less satisfactory and reliable for use in other cases.

The last five years have produced a whole new list of dry records and shortages in city supplies that compel a radical revision of the storage units that have been used. The abundance of these records is in part due to some very dry seasons; but perhaps equally because more streams are being fully used or gaged, and because conditions are being recorded that otherwise might have passed without notice.

The committee has performed a substantial service in collecting and arranging in convenient and readily applied form the more important of these data, and in comparing them with the earlier ones that until now have been so largely used as a more or less general basis for estimate.

The last pages of the report seem to indicate that these new records, or some of them selected and supposed to be applicable to a given case, will be used from time to time as a basis for estimating the required storage on other and ungaged streams; but the wide divergence of the results, more apparent from this report than ever before, will tend to keep a cautious engineer from going far in that direction. The wide divergencies in the records of different streams, and of the same stream at different times, should naturally stimulate an interest in and a more rational study of the effect of peculiarities of different areas in their power of receiving, holding and throwing off the rain that falls upon them, and in the law that governs the periodical fluctuations in flow, and so of their yields and storage requirements. There is a good prospect of success in doing this. At first glance the incessant change in daily, monthly and annual runoff quantities seems hopelessly complex. No law is apparent in it. No series of such records is ever repeated, and the dry years of the present are not like the dry years of 30 years ago. On the Sudbury they are drier; on the Croton, less dry; but they are never just the same. But further study shows that these flows, erratic as they seem to be, do follow a fixed law. The law is complex and hard to make out, but none the less definite and certain in its application when once it is understood.

The hydraulic method of calculation in common use up to the present time is based on the tacit but erroneous assumption that the driest time in the record period will be periodically repeated, and that the record of the past measures what is to be anticipated in the future. But all experience and the committee's data are against the assumption. Dry periods will come; and it is only a question of how long it will be before a new low flow record is made upon any stream; and when it is made the chances are more than even that it will be less by a substantial percentage than the record one to date. It is time that this should be more fully realized, and that study be made of the series represented by the flow records to determine more definitely its law, and to find better and more reliable ways of applying that law to water supply conditions.

Electrolytic Treatment of Sewage

IN last week's issue of this journal there was published a report made by P. M. Travis, chemist of the Borough of Queens, New York City, upon some tests made at the Elmhurst Disposal Plant of an electrolytic method of sewage treatment devised by C. P. Landreth, of Philadelphia. Mr. Travis' conclusions that "startling and excellent results" have been obtained at low cost, compared with the costs and results obtained by other treatments and that "beyond doubt a satisfactory method of sewage disposal has at last been accomplished" are of so broad and sweeping a character as to justify a somewhat detailed analysis of his published data.

The design of the apparatus involves no features that are essentially new, except that certain of the electrodes are of "iron composition" and that the sewage between these electrodes is agitated by paddle wheels. The sewage is passed continuously through the ⅜-in. spacing between electrodes, passing from one of these spaces to the next through a hole (dimensions not given) in the corner of the intervening electrode. There are altogether 55 of these chambers, making a circuitous passage approximately 80 ft. in length, 10 in. in width and ⅜ in. in thickness. In the course of its flow through the apparatus the sewage also passes through 55 holes of unstated dimension. No estimate has been made of the amount of energy required to pump over 1000 gal. of sewage per hour through this device.

The sewage upon leaving this apparatus passes to a sedimentation tank having a capacity of approximately 3000 gal., which provides, assuming the apparatus to have been run at the specified rate of 25,000 gal. per day, a sedimentation period of 2.9 hr., although it is stated that the time of passage through this tank is from 10 min. to ½ hr. The clarified liquid then passes to a still larger tank having a storage capacity of approximately two and a half times the daily output of the apparatus. Analyses are given of the effluents from each of these three parts of the equipment. Average bacteriological reductions of 99.8 per cent, based upon 48-hr. incubation at 37 deg., were recorded after passage through the first sedimentation tank. Actual numbers of bacteria observed at this point range from 95 to 1560 per cubic centimeter. Dissolved oxygen was increased almost invariably after passing the electrolytic apparatus and oxygen consumed values, two tests, showed reductions of approximately 50 per cent after sedimentation. The settled effluent was stable after 10 days, one test only being recorded. Two tests showed turbidity reductions of 80 per cent and 91 per cent respectively.

Except for the single stability test, which is of little significance in the presence of such low numbers of bacteria and especially of some possible residual disinfectant, these figures indicate an extremely satisfactory degree of purification. It is a matter of some interest, therefore, to determine, if possible, by what means the results have been brought about.

Lime, equivalent to 1257 lb. of pure calcium oxide or 1600 lb. of commercial lime per million gallons of sewage treated, is added in an emulsion just before the sewage passes to the iron electrodes. The latter are connected in such a way that eight of the electrodes are in series, while the carbon electrodes are apparently all in parallel. It is stated that nine-tenths of the current passes through the carbon electrodes and one-tenth through the iron. Electrical energy is furnished at the rate of 144 kw hours per million gallons of sewage, the actual voltage being 7½. The current, for 25,000 gal. of sewage per day, is stated to be from 18 to 20 amp, although actual figures are given for 30 amp. It is stated that the iron electrodes are not seriously affected, although they are kept bright. Actual determinations of iron, one 24-hr. test only, showed an increase of two parts per million in the effluent. A theoretical electrolytic solution of iron under the conditions obtaining, as nearly as can be determined from the published figures, would give 4.2 parts, so that it is apparent that this process does not differ markedly from others of a similar nature in which the precipitating effect has been shown to be due largely to the production of iron salts. The increase in iron actually determined would be equivalent to 81 lb. of pure copperas per million gallons of sewage. There is also an electro-chemical production of 5.2 parts per million of available chlorine at the iron electrodes alone, although these consume but one-tenth of the current used.

The actual amount of lime added is about double that used at Worcester in straight chemical precipitation. The claim that a portion of this lime was necessary to soften the water, based upon analysis of the city water itself, is beside the point, since the presence of hardness constituents in sewage would not interfere with the precipitating action of the lime, and the sewage has already been softened by soap. Figures are given showing a reduction in hardness of from 144 to 43 parts per million, although the lime added is sufficient to bring about a total reduction even assuming it to be wholly bicarbonate hardness and to leave an excess hardness of 207 parts per million.

It must be obvious, therefore, that the electrolytic features of this treatment comprise essentially the production of chlorine or hypochlorite and the solution of iron and possibly of other metals of even more strongly germicidal nature. If, for example, the "iron composition" were to contain a small proportion of copper, very effective germicidal results would be observed. In addition to this electrolytic activity there is undoubtedly a strong precipitation due to the admixture of a dose of lime double that ordinarily used for the purpose, and there is the further distinct advantage of a very powerful mixing and agitation obtained by forcing a stream of sewage at high velocity through small holes and narrow spaces. This agitation alone, acting upon the principle of Travis' "colloiders," would greatly facilitate precipitation without the addition of lime or iron.

Finally, as to cost, Mr. Travis' optimistic statements do not appear to be borne out by his figures. He estimates a cost for electric current alone of $4.32 per million gallons, and for lime, $3.77 per million gallons, a total cost of $8.09. Cost of pumping the sewage through the apparatus, of agitating the many paddle wheels, of plate renewal, of the three-hour sedimentation tanks, and of capital charges on the electrolytic apparatus have been ignored.

Finally, and most important, not one word is said about the sludge, except that it is not offensive and can be pressed. With the excessive amount of lime used, between 5000 and 10,000 gal. of sludge per million gallons of sewage treated will remain to be disposed of. It is unfortunate that the exact quantities have not been reported. As against the $4.32 for current to produce the disinfectant, the Technology experiments on sewage disinfection show an even greater bacteriological efficiency (99.96 per cent) with 10 parts per million of available chlorine as hypochlorite at a cost for chemical alone of $3, or a total cost, including labor and capital charges, of $3.39.

It has repeatedly been shown that the small-scale production of disinfectant by electro-chemical methods cannot compete with bleaching powder under present market conditions. It would be of interest to determine whether equally satisfactory results could not be obtained without the use of electric current by the application to the Elmhurst sewage of 10 parts per million of available chlorine as hypochlorite and 2 parts per million of iron as copperas in addition to the quantities of lime used in this installation, and with a three-hour period of sedimentation. Experience elsewhere would indicate that such would be the case.

Developing the Track Layout of a Large and Busy Passenger Terminal

Evolution and Execution of Plan for Rebuilding Jersey City Terminal of Central Railroad of New Jersey to Meet Increased Traffic Needs

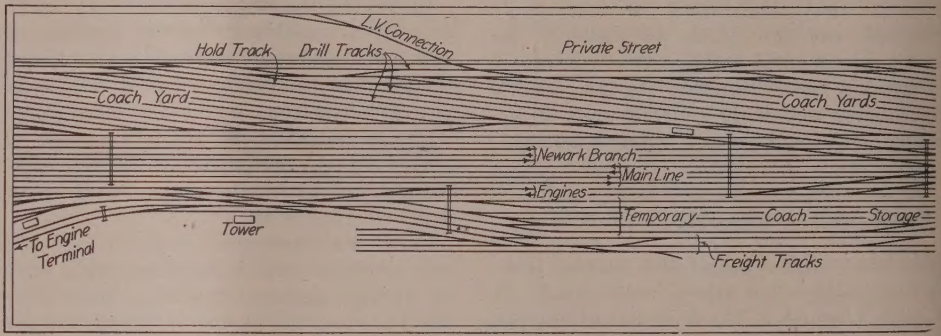
QUITE as important, from the point of view of railroad operation, as the reconstruction of the terminal station, trainshed and ferryhouse of the Central Railroad of New Jersey at Jersey City (see Engineering Record of Jan. 4, 1913, page 6; Jan. 31, 1914, page 146; May 30, 1914, page 622, and June 27, 1914, page 733) is the enlargement and rearrangement of the track facilities now well under way. Like all projects of a similar nature the layout finally adopted was evolved only after years of careful study, in which plan after plan was made, analyzed and developed by one change after another.

It is believed that the present plan will be carried out in its essential features, although minor revisions are almost inevitable. The new trainshed envelops the site of the old, extending beyond it to the north, south and west, and this, with the use of multiple ladders and easier approach angles, brings the new throat considerably west of the old. To date the additional width of trainshed has been built, together with the tracks serving it, which have been connected at the old throat; the old trainshed has been replaced by the new and the new tracks have also been connected up to the old ladders; the new signal tower is erected and the interlocking and track changes are under way.

Conditions to Be Met

In working out the general plan a number of conditions peculiar to this terminal had to be met. This railroad, like the West Shore, depends entirely upon ferry service between its terminal and New York City. This means the grouping of trains to connect with the boats, and the consequent increased congestion at intervals during the rush hours. Suburban traffic is heavy, and an important element is the high-speed hourly service between New York and Philadelphia. These fast trains are short, whereas many of the suburban trains are very long, thus reversing the usual conditions. There are also the slower and heavier trains of the Baltimore & Ohio and the Lehigh Valley—comparatively few in number, but often run in two or more sections, which adds considerably to the operating difficulties.

The main line runs west from the terminal to Communipaw, a distance of about 1¼ mi., and then turns south through Bayonne. At Elizabethport, about 10 mi. out, the line to Perth Amboy and the coast resorts branches off. The main line is four-tracked for some 30 mi. except for a stretch over Newark Bay about 1 mi. in length, which is double-tracked. Next to the main line on the north side from the terminal to Communipaw are the two independent main tracks of the Newark branch. These tracks continue west at Communipaw and another line from Newark to Elizabethport completes an alternative outlet for all main-line business. The fast Philadelphia and Washington trains use the main line, as do the main line trains of the Central Railroad of New Jersey and a large percentage of the shore trains. The Lehigh Valley and a few of the main-line and shore trains having Newark connections use the Newark branch. Before the improvements started the main-line from the terminal to Communipaw was only double-tracked, the Newark tracks taking the place of the third and fourth tracks. When the temporary rearrangement now in service was installed an additional track south of the four main tracks was connected up as an additional eastbound main. This is the track now running behind the old signal tower.

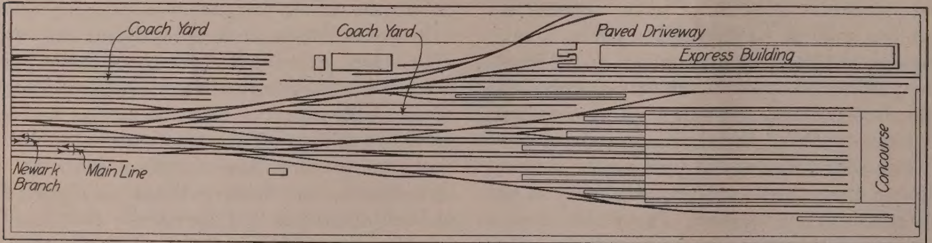


PLAN OF ULTIMATE DEVELOPMENT, SHOWING PLATFORM TRACKS, LADDERS,

As the Lehigh Valley has only been using the terminal a year or so, it was not a factor in the original problem, but certain changes have been made to accommodate its traffic. Its train service is only a small percentage of the total, however.

Original Layout

Comparison between the original layout and the ultimate is afforded by the illustrations. The old trainshed covered twelve tracks, with narrow platforms between. Two short additional tracks had been built on the south side. The middle platforms were extended far beyond the sheds to accommodate the longest trains; the outside tracks would not hold these trains. It will be seen that the outside tracks on each side depended upon a single ladder, and that the runaround tracks only afforded two simultaneous movements in each direction on certain pairs of tracks, without eliminating the danger of blockade of a considerable part of the terminal by a single derailment.



PLAN OF OLD TRACK LAYOUT AT JERSEY CITY PASSENGER TERMINAL

Until a few years ago all of the space south of the terminal and ladders was given over to freight service. This meant that to get empty passenger trains into or out of the south side of the trainshed it was necessary to carry them across the main tracks, and to eliminate this feature several tracks immediately south of the old mains were connected up to form a temporary storage coach yard. This connection, however, which is not shown, reached only a few of the trainshed tracks.

Some distance north of the main tracks runs a private street, which is parallel to the center line and is the only roadway reaching the terminal. Fronting on this street, north of the station, is the express building. The remainder of the space between the main track and the street, from the terminal to Communipaw, about 1 mi. long and 200 ft. wide, was occupied by coach yards, two engine houses and a coal trestle. The engine facilities took a large part of this space, and the coach tracks, mostly on 12-ft. centers, made proper cleaning of the cars difficult.

Station Tracks

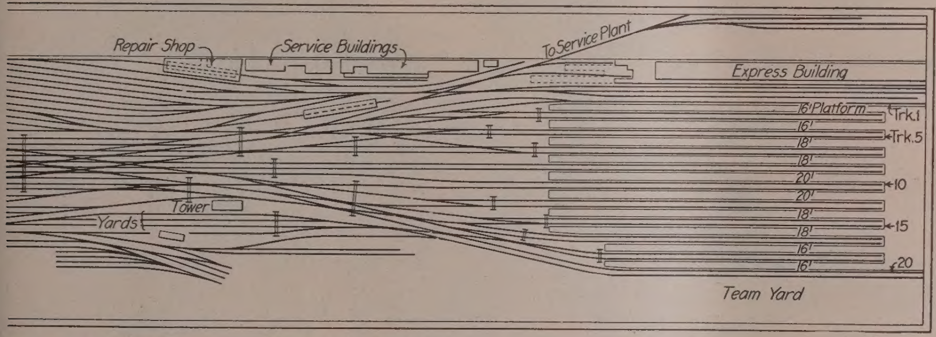
In planning the new layout consideration was naturally given first to the trackage of the station itself. While the aim was to provide enough tracks for a long time to come, it was recognized that aside from a small amount of waste space between the old station and the express tracks any additional width must be at the expense of the freight layout. The use of longer platforms and the introduction of center columns as required by the Bush type of trainshed meant that the platforms must be wider than the old.

Twenty tracks, as compared with the fourteen of the old arrangement, were fixed upon as ample to meet the requirements, assuming that the twenty would be more adequately connected than the old with the main tracks. The varying width of platform, from 20 ft. on the inside to 16 ft. on the outside, was a compromise. The 20-ft.

width was desired throughout, but it was decided that with 20 ft. for the two middle platforms a 24-ft strip might well be yielded to the freight department by narrowing the side platforms, where the trains are expected to be shorter. With the overall width of the trainshed layout thus determined, the north line was fixed by the three tracks on 12-ft. centers serving the express building. This brought the center line of the trainshed 28.55 ft. south of the monumented center line, which was between the main tracks.

FLEXIBILITY DEMANDED

It was felt that the original layout had less need for more station tracks than for more ample and flexible connections between them and the main tracks and yards. It was determined that the ultimate plan must, through an abundance of ladders, crossovers and slip switches, allow as many simultaneous train movements as possible and eliminate the chance of tying up any considerable part of the terminal by any single accident.



MAIN TRACKS, COACH YARDS, SIGNAL BRIDGES AND MAIN BUILDINGS

New engine facilities were needed, and in order to release the space north of the main tracks for coach yards, and at the same time accommodate the freight engines from the freight yards to the south, the site for the new engine terminal was chosen on the south side of the main tracks at Communipaw. Two large reinforced-concrete engine houses with a modern coaling station have been built by Westinghouse, Church, Kerr & Company, of New York City, under direction of the engineering department of the railroad, and were opened for service in May. Another requirement of the problem was, therefore, a pair of engine tracks running from the station out to the engine house on the south side of the main track.

A feature recently adopted is an additional westbound main track for the Newark branch. The main reason for this is that often a through train going out over the Newark branch and a quick-moving local Newark train are scheduled to start at the same time. With two westbound tracks the local can get away ahead of the other, be overtaken while making the stop at Communipaw, and close in behind the through train without loss of time to either. At the same time a crossover system at Communipaw will make possible the use of the extra Newark track for main-line service.

LACK OF SYMMETRY

It will be noted that the three Newark main tracks are all north of the main-line tracks. The center one of the system of seven main tracks is considerably more than 28.55 ft. north of the center line of the trainshed. The eccentricity is, in fact, about 48 ft. Summing up, then, the problem was to connect up in the most flexible manner a system of twenty platform tracks with a system of seven main tracks 48 ft. off center, provide substantially as flexible connections for the two engine tracks, preserve the temporary storage yard on the south side, regarded as vitally important, utilize the rather limited space on the north side to the best advantage for storing and cleaning coaches, and reach in an adequate manner the express building and the Lehigh Valley coach yard north of the private street.

One of the first important details to be settled was the frog angle for the main ladder system. While No. 10s were considered ideal, their use would have brought the main ladders dividing the coach yards so far west as to reduce to a considerable extent the west portion—the only part reached directly from every platform track. Furthermore, there would have been a greater waste of space in the triangle between the ladders and trainshed than with a smaller frog, and the length of interlocking would have been greater. No. 8s were considered, but were thought to give too sharp curves for present-day equipment. No. 9s were, therefore, adopted. At first it was intended to use No. 9s only within the interlocking and No. 8s outside, but the ultimate plan makes the use of No. 9s throughout easy, and nothing smaller will be used except in a few places.

The first plan that presented itself was a pair of ladders all the way across in each direction intersecting at the main tracks in four diamonds and two independent ladders on the north side carrying the Newark tracks independently to the most northerly platforms. On account of the eccentricity of the platform and main tracks this made the south ladders extremely long and brought the diamond crossings far to the west in order to reach the most southerly tracks, this in turn bringing the north ladders too far west and making the north platform tracks entirely too long. It also made the south eleven platform tracks dependent upon two ladders, while the north nine were served by four.

To shorten the layout and remedy this lack of balance a double throw on the south side was introduced, making the five south tracks dependent solely on the secondary pair of ladders, and so making it possible to pull the diamond crossings east and eliminate the waste of space in the north body tracks. At the same time the superfluous fourth ladder on the north side was eliminated by merging one of the Newark ladders with one of the main ladders. This is essentially the general scheme adopted, modified in numerous details for special reasons.

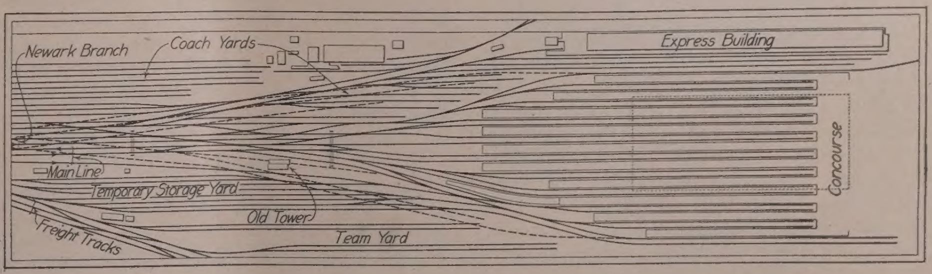
LONGITUDINAL POSITION

With the general arrangement of ladders fixed the next thing to determine was the longitudinal position as a whole. The general length of the trainshed has been fixed at 800 ft. to accommodate eleven 70-ft. coaches. On the north side it was thought that only the outside ladder need reach the outside platform track, letting the other two ladders reach as many tracks as possible and allow space for a signal beyond the platform. At the same time a suitable connection with the express-building tracks was imperative and the adjustment of the switches to allow all the movements obtained between the main tracks, express tracks, coach yards and service connection north of the street fixed within narrow limits the double slip opposite the private-car shed and the crossing between the express connection and the coach-yard connection at that point.

With 13-ft. centers for the main tracks and No. 9 ladders the centers between pairs of ladders are fixed at 25.84 ft. This means a longitudinal distance between ladders of about 233 ft. Allowing the conditions cited to fix the north ladders, the alternative for the south side would be either to encroach on the trainsheds, as shown, or move the entire south ladder system bodily west 233 ft., bringing the northerly ladder of the pair to the position of the southerly one. As the shortening of the last two platforms to a capacity of nine coaches was not deemed objectionable, the encroachment on the trainshed was chosen. Finally, the entire ladder framework was crowded eastward, curving the outside platforms as much as possible without encroaching on the trainshed columns or canopies, and at the same time making sure that the express connection could be made.

COACH YARD

The main coach yard was the subject of considerable study. The total space available is none too large and is permanently limited by the private street and the Lehigh Valley freight crossing at Communipaw. The chief question to be settled,



PRESENT TRANSITIONAL LAYOUT—ULTIMATE LADDERS IN HEAVY DASHES
Light dots indicate old train shed

therefore, was whether the maximum car capacity should be obtained at the sacrifice of space between tracks to facilitate cleaning the coaches or whether fewer tracks should be laid with wider spaces between them. Consideration was also given to the adoption of either stub or through tracks. It was early decided to use through tracks on 14-ft. centers in the space beyond the thoroughfares formed by the extension of the south ladders of the station layout. The study, therefore, narrowed down to the space east of the thoroughfares, and here a number of possibilities offered. Studies were made for tracks parallel to the thoroughfares, parallel to the main tracks and parallel to the north ladders of the station layout. In some of these studies stub tracks were shown, as this space, or a part of it, was considered the best for handling Pullman and other high-class equipment. In view of the advantage of having tracks from which trains could be pushed direct to a number of the station tracks, however, and the frequent need of adding extra cars at the eleventh hour, it was decided to use through tracks. This readily led to placing these tracks parallel to the thoroughfares previously mentioned.

When the project is completed it is proposed to use station tracks 1, 2 and 3 for local Newark trains and tracks 4, 5, 6 and 7 for Lehigh Valley and other trains using the Newark line. It will be seen that all of the latter four are reached direct from the most easterly ladder, and that all of the seven connect directly with the coach yards without fouling the main tracks. Six coach tracks on alternate centers of 17 and 14 ft. to facilitate cleaning are reached direct from these seven station tracks. One of the six is a temporary hold track for Lehigh Valley trains, which enter it from the track shown across the private street. The five other tracks are expected to take care of the bulk of the Baltimore & Ohio trains and the Pullmans for other service, but the seven tracks immediately north, spaced in the same manner, are readily reached by a back-up movement. Multiple leads for the coach-track units allow the use of numerous engines at one time. A shed large enough for two private cars and a repair shop with drop pit, also large enough for two coaches, are also provided.

The design for the temporary storage yard on the south side has undergone a number of changes. Starting with one large yard connecting direct with only the seven southerly tracks, the layout has been split up into three parts, one or more of which reaches ten of the station tracks. This means that all but three of the twenty tracks can be cleared without crossing the main tracks. The two engine tracks also reach the southerly ten without fouling the mains.

SIGNALS

Co-operating with the signal and operating departments, the engineering department has carefully worked out the arrangement of signals, making modifications in the plans where needed. The aim has been to allow each train to advance as far as possible so as to minimize the time the signals must be set for a movement fouling other moves being made simultaneously. To bring this about no less than sixteen signal bridges will be used, in addition to a number of single masts. One of these bridges will span twelve tracks. Distance as well as home signals will be provided at each block, so that enginemen may know more definitely the condition of the track ahead and so regulate their speed.

Looking at the possibilities of the layout, as a whole, it will be seen that simultaneous movements can be made on each of the seven main tracks, and, in addition, using certain combinations of tracks, an engine can enter or leave the station and an empty train can be taken to or from the temporary storage yard. Each ladder reaches from three to seven tracks direct, and the crossovers and slip switches increase the possibilities. Not more than two tracks are dependent upon any one switch, and the terminal may be considered less liable to blockade than the main tracks themselves.

EXECUTION OF PLAN

The execution of the plan to date has, in the main, been described in the articles mentioned in the first paragraph. The new tracks outside of the old trainshed were laid on their final location and were swung to temporary connections with the old ladders. Owing to the narrowness of the old platforms this actually gave twenty-one tracks and made it possible to put those under the old shed out of service a few at a time and replace them with the new tracks and trainshed. These tracks were in turn connected to the old throat and are still so connected. On account of the shortness of the old layout it has been impossible to complete the trainshed to its whole length. The two northerly and four southerly platforms are from 130 to 270 ft. short.

To accommodate these temporary additions to the old layout it was necessary to enlarge the old signal tower and install a supplementary electro-pneumatic interlocking machine. The new signal tower is constructed and a series of shifts is being studied out to bring about the transition from the old layout to the new without hampering the daily operation of the terminal. The second shift is under way.

It is the policy of this road to figure its track work in the quiet of the office rather than in the grime and tumult of the railroad yard. "Staking-out plans" are, therefore, drawn, showing center lines of tracks and points of intersection of curves and turnouts, as well as points of curvature and tangency, and indicating thereon exact figures, so that the work of the man in the field is reduced to a mere laying out of distances and angles.

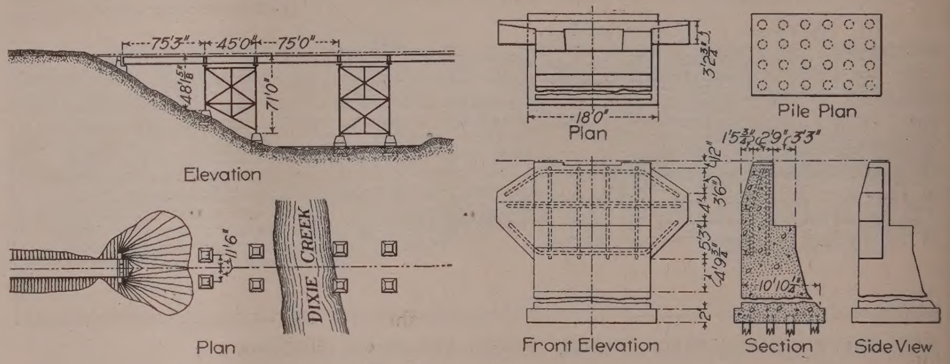
A complete staking-out plan has been made for this work at Jersey City—a plan much more complex than any previously attempted. With so many parallel ladders and body tracks there are naturally numerous duplications of curves. To simplify the plan and avoid recording complete figures on each of these curves the repeating curves have been given index letters and a table has been made in a corner of the plan, showing the index letter, central angle, degree of curvature, tangent distance, length of curve and external. On the plan itself it is, therefore, necessary only to record the index letter and the stationing of the point of intersection.

The terminal improvement is being carried on under the supervision of the engineering department of the Central Railroad of New Jersey, of which Joseph O. Osgood is chief engineer.

Concrete Abutment with Cantilever Wing Walls

Saving Material in a Canadian Pacific Railway Bridge Where Ordinary Stub Abutments Were Not Desirable

THE abutments for the Canadian Pacific Railway viaduct over Dixie Creek near Agincourt, Ont., are gravity retaining walls with pile foundations. The lower portion of the abutment has a width of 16 ft. transverse to the track, but the width of the upper part is increased to 27 ft. by cantilever extensions on each side, which retain the upper part of the fill but allow the slopes to swing around the abutment under them at a depth of 9 ft. below the base of rail, thus forming a stable embankment in front of the lower part of the abutment wall and reducing the pressure on the latter.



PART PLAN AND PROFILE OF BRIDGE AND DETAILS OF ABUTMENT

The abutment has a height of about 24 ft. above the pile tops and resists the pressure of a fill 30 ft. deep. The bending moments on the cantilever wings are resisted by old rails embedded horizontally in the concrete and bearing against vertical rails in the main body of the abutment.

An estimated saving of about 200 cu. yd. of concrete, effecting an economy of about $2000, was made by using this type of abutment rather than a more massive construction with full-depth wing walls to resist the heavy earth pressure.

(Another method of saving concrete in the wing walls is that employed by the Louisville & Nashville Railroad in some of its recent bridges, described and illustrated in the Engineering Record of Aug. 2, 1913, page 129, and Sept. 6, 1913, page 270. The Louisville & Nashville method, more especially aimed at keeping the fill off the low bridge seats of deck structures, is to turn the back wall back parallel to the track, making the top of the cantilever horizontal and the bottom parallel to the natural slope of the fill.)

The Canadian Pacific work was designed and executed under the direction of the engineering department, of which P. B. Motley is bridge engineer.

Floating Lock-Gate Lifter

Steel Pontoon and Derrick Built and Used for Placing into Position Gate Leaves in Trent Canal, Ontario

A STEEL pontoon lock-gate lifter has been recently built for the Department of Railways and Canals of Canada for service on the Trent Canal in Ontario. It was designed and built to lift and place into position the lock gates, and its capacity of 50 tons and clearance of 37 ft. above the deck will enable it to step any of the mitred gates throughout the entire length of the canal. The general design comprises a structural-steel collapsible derrick mounted on a steel pontoon, with separate steam engines for each operation.

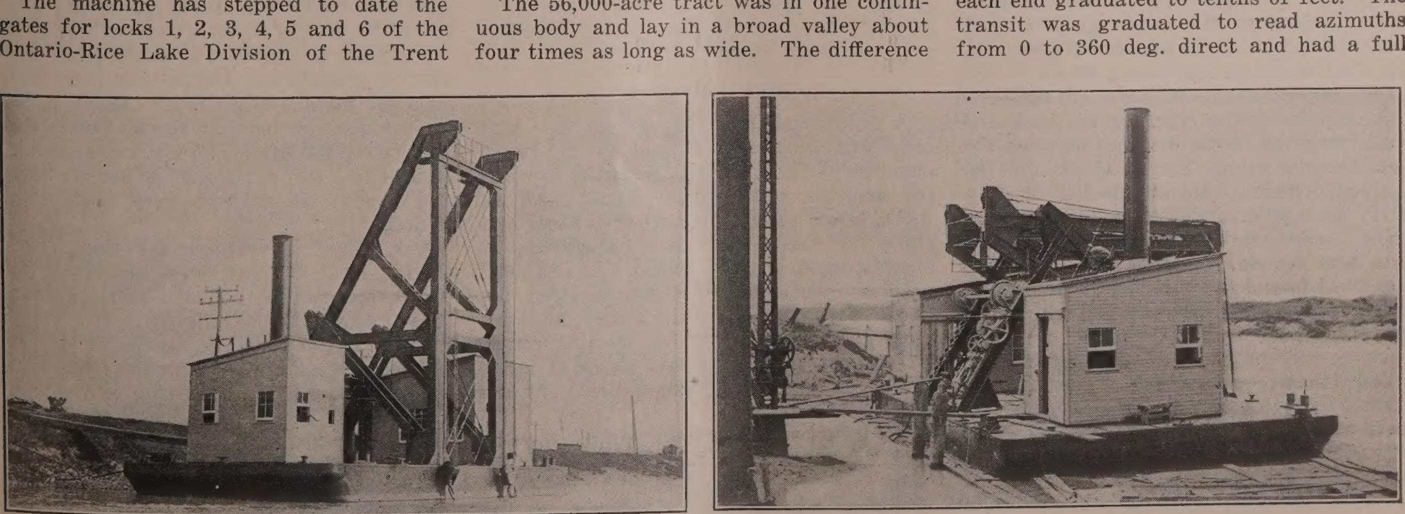
The pontoon supporting the derrick is made of steel plating with extra strong steel framework, there being two longitudinal and three transverse trusses, so as to provide for the severe loads it will have to bear. The hull is constructed with rounded bilges and each end has a rake of 45 deg. The length is 55 ft., beam 27½ ft. and depth 9 ft.

The derrick is built of structural steel in two units. When in working position the derrick is erect, as shown in the first illustration. In transporting the lifter from one lock to another, the upper part of derrick is lowered where necessary, as shown in the second view, which allows of its passage under overhead bridges along the canal. The operation of raising and lowering the derrick is performed by a 6 x 6 double-cylinder engine mounted on one of the back legs. Two swivel hook padlocks are suspended, one from each overhanging top of the front legs of the derrick, each carrying 8 parts of ⅞-in. steel cable. The main engine has 9 x 9 double cylinders and double drums. The operating levers are brought to one position for the convenience of the engineer.

Two movable ballast cars under deck keep the pontoon on an even keel. Each car is moved by a steel screw operated by an independent 6 x 6 reversing engine. These engines are controlled by pendulum governors, automatically shifting the ballast to the proper position to put the pontoon on an even keel, whether it is under load or light, with the derrick upright or folded. In addition to the automatic control, the ballast-car engines can be operated from the engine room above deck. Dial indicators are provided to show the position of the ballast cars at all times.

The machine has stepped to date the gates for locks 1, 2, 3, 4, 5 and 6 of the Ontario-Rice Lake Division of the Trent Canal, and in operation is said to have met all expectations. The total time for stepping each leaf from picking up in water to releasing in gate recess varied from 20 to 40 min., according as an upper or a lower gate leaf was handled. At lock 3 the lower gates are 37 ft. high over timbers, and these represent the heaviest gates the lifter is designed or will be called upon to handle.

The lifter was built by M. Beatty & Son, Ltd., of Welland, Ontario.



LOCK-GATE LIFTER ERECT FOR SERVICE, AND WITH TOP OF DERRICK LOWERED TO PASS UNDER BRIDGES

Speed on Topographic Surveys

Number of Shots Per Day Means Little without Full Information as to Nature of Country and Amount of Detail and Accuracy Required

By LYMAN E. BISHOP

Civil, Hydraulic and Irrigation Engineer, Denver

THE writer has read with considerable interest the article entitled "Six Hundred Transit Shots in Eight Hours," published in the Engineering Record of June 6, page 639. It is due the profession that record runs of this kind should be very carefully explained and that all of the facts relative to the kind, amount and accuracy of the work be given in sufficient detail that readers may have no doubts as to what was accomplished and the results obtained. In the article referred to it is stated that on a topographical survey one transitman with two rodmen took 600 transit shots in 8 hr. and kept his own notes. Presumably the stadia method was in use, and for each transit shot the transitman had to take and record at least the usual three readings—distance, azimuth and vertical angle. It does not seem probable that all of the shots were taken from one transit point, and if it be assumed that eight stadia stations were occupied during the day and that between setups 5 min. (this is a minimum allowance) were consumed, during which time no side shots were taken, then we have on the average one shot taken every 44 sec. In this time three readings were taken, and these readings, requiring on the average eleven figures, are recorded. In the foregoing analysis the efficiency of the transitman and his rodmen is taken at 100 per cent.

SURVEYS MADE BY THE WRITER

The writer has been associated with several topographic surveys and in the last five years has had responsible charge of two, one of 56,000 and another of 53,000 acres. Considerable study has been made of methods and their relative efficiency, accuracy and cost, and on the surveys mentioned the secondary control was obtained with transit and stadia.

The 56,000-acre tract was in one continuous body and lay in a broad valley about four times as long as wide. The difference of elevation over the entire tract was about 400 ft. In 30 per cent of the sections the average difference of elevation in one section was about 70 ft., and the average difference of elevation in one section in the other 70 per cent was about 40 ft. There was practically no timber on the area mapped; the country was open and would be classed as rolling prairie. About 20 per cent of the tract was rough and broken up by heavy draws, sharp ridges, knolls, basins and potholes. At least 40 per cent had the usual culture of farming and cattle country—cultivated fields, ditches, fences, roads and ranches.

Sufficient data were obtained in the field to enable topographic maps of each section (640 acres) to be prepared on a scale of 200 ft. to the inch, showing 2-ft. contours. The main features shown on these topographic maps may be classed under the following heads: (1) Water, including lakes, streams, canals, laterals, swamps, etc.; (2) Relief, including the graphical representation of the relative elevations of the hills, valleys, knolls and sinks by contours, and a classification of the land under consideration, as sandy, clay loam, shale hills, etc.; (3) Culture, work of man, including ranches, wagon roads, fences, section corners and boundary lines. The finished map showed all of this information for each section. The usual conventional signs were used, but the work on the tracing of the topographic maps was all executed in black waterproof ink, so that all prints from these tracings have a uniform appearance and are equally legible in all particulars.

PRIMARY AND SECONDARY CONTROL

The horizontal primary control of the maps was obtained with an engineer's transit, reading to single minutes, and an ordinary 100-ft. steel tape, with the foot at each end graduated to tenths of feet. The transit was graduated to read azimuths from 0 to 360 deg. direct and had a full vertical circle reading to single minutes and a reversible level telescope. Direct solar observations were taken for the determination of true meridian. Vertical primary control was obtained with an ordinary 18-in. wye level and a 13-ft. Philadelphia level rod. All turning points and bench marks were read to the nearest hundredth of a foot. From transit points, the elevations of which were determined by the vertical control, the details for the map or the secondary control were obtained by stadia. Stadia distances were read to the nearest 5 ft. and azimuths to the nearest 15 min. For the important culture shots the stadia was read with the maximum obtainable accuracy. All vertical angles were read to the nearest minute.

The sections were worked up in tiers 1 mi. wide and extended across the total length of the area mapped. Preference was given to working up the tiers in north-and-south lengths with an east-and-west width of 1 mi. By planning the work in this manner the error due to running east-and-west lines was compensated and there was no necessity for offsets in running lines, for the progress of the base line was in either a north or a south principal direction.

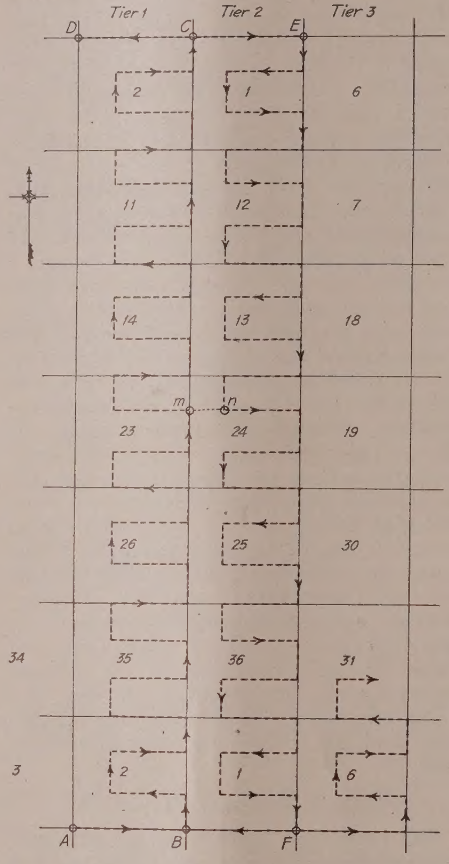
ORGANIZATION

The organization of the field party consisted of fourteen men with the following ratings: Chief of party, transitman, levelman, recorder, level rodman, four stadia rodmen, rear chainman, draftsman, assistant draftsman, teamster and cook. The transit party was under the charge of the transitman, who had a recorder and four stadia rodmen for his assistants. The level party was under the direction of the levelman, who had a rodman and a rear chainman for assistants. The draftsman had one assistant in the field office to aid in the preparation of the detailed maps. The teamster was an extra man reporting to either field party as directed.

The chief of party established all transit points. His flag was set on line by the transitman, or, if the topography did not permit, approximately on line. The level rodman, as head chainman, using his rod as a picket, was lined in by the rear chainman, and they proceeded toward the picket, chaining the horizontal distance between transit points. During the measurement of this base line the head chainman gave the levelman his profile readings and turns and noted in his peg book the level readings of turning points and the plus to all culture crossed by the base line. When the level party arrived at the head flag a transit point was established, and the transitman, who had been reading stadia shots in the meantime, read the azimuth to the new transit point (after checking his back azimuth) and the stadia distance between the two transit points for a check on the chained distance. Meanwhile the chief of party had proceeded and selected a new transit point, and as soon as the transitman was set up, the chief-of-party's flag was lined in and the party again proceeded.

The progress of the work of both parties was so arranged that the work of either party could proceed uninterrupted with either transit or level party ahead. The transit party was often a mile ahead of the level party, and, on the other hand, quite often the level party was ahead. Whichever party was behind would always be on the move to catch up and the party ahead would try to keep its lead. When the transit party was ahead there was then time to take extra readings of the topography, for the country would be particularly rough, steep and broken, with a considerable difference of elevation; otherwise the level would not be behind. In plotting up the detailed map it was a great deal better to have too many elevations, when the country was broken, than not enough.

The chief of party kept a set of traverse notes and worked up latitudes and departures, on a slide rule, in the field, so that he always knew his location. He also kept a sketch of the country being mapped, and this sketch showed the fences, ranches, hills and all important salient features of the culture, relief, class of soil, etc. After the chief had his flag established there was then time for him to work on his notes and sketches and tie in features of importance by pacing, using a pocket compass. This sketch map proved invaluable to the chief of party later, at the time that he checked over the detail maps.



METHOD OF TRAVERSING SECTIONS

SIGNAL SYSTEM

A code of signals was devised, and this code was learned and used by all party members. These signals included most of the common conventional signs, such as ditch, fence, road, figures (one to zero) and signs for knoll, ridge, etc. This code of signals saved a great deal of the ordinary needless confusion in communication between the party members across large intervening distances, during weather conditions when even the most vigorous lungs would not be able to communicate the desired information.

Breakfast was served on working days at 6:15 a. m., and the men were always on time. It was known that tardiness to breakfast was ample justification for the dismissal of the offender. The field party left camp for the work at 7 a. m. One hour under ordinary conditions was taken about noon for lunch. This one hour was figured from the time that the party quit work to leave for the noon camp to the time that the party left the noon camp to return to their work. The party quit work for the day in time to arrive at camp at 6 p. m. Supper was served at 6:30 p. m. Punctuality was very carefully observed by all party members, for one tardy or careless individual who continually neglects some item until the last moment would hold up the entire party, and with a party of this size time was a very valuable asset in the progress, results and cost of the work.

RUNNING THE BASE LINE

The adopted method of running the base line is shown, the arrows indicating the direction in which the line was run. Assuming that the survey had been completed for the tier of sections west of tier 1, point *A*, the southeast corner of Section 3 was taken as Station 0 of the base-line survey for tier 1, and the co-ordinates of *A* were taken as 0, 0. All plotting of base lines was done by latitudes and departures. The chained traverse base line was then run 1 mi. east along the section line, obtaining the tie to the south one-quarter corner of Section 2 on the way to the point *B*, and the section corner tie was obtained either by making the corner a transit point or by a side shot. Point *B* was the closing point for the survey of tier 2. The base-line traverse was then run a third of a mile north along the section line, two-thirds of a mile west, a third of a mile north, two-thirds of a mile east and a third of a mile north along the section line to the northeast corner of Section 2. A chained angle tie was made from the nearest hub to the east one-quarter corner of Section 2. In this manner the base-line traverse covered the tier of sections from south to north in the direction indicated by the arrows. Diligent search was made for all section corners and careful chained angle ties were obtained to all Government corners during the progress of the base-line survey. Wherever possible transit points were established on the Government corners.

The point *C* was established on or near the northeast corner of Section 2 of the next township, and *C* was the initial point for the survey of tier 2, as *A* was for tier 1. From *C* the traverse was continued a mile west along the section line, making the closure of the tier at *D*, which point had been previously established during the survey of the tier of sections west of tier 1.

Adopting this method of running the base line, no point in any section was more than 1200 ft. distant from some transit point, for the distance between transit points was kept below 1800 ft. The maximum amount of base line was run along the section lines, and ties to all corners were readily obtained.

The base-line traverse for tier 2 was started at *C*, the northwest corner of Section 1, and run as indicated by the arrows. It will be noted that the traverse for tier 2 has ⅓ mi. of base line parallel to the gap in the traverse of tier 1 on the east. The survey of tier 2 was closed up on tier 1 at the point *B* and the initial point of the survey for tier 3 was at *F*.

Cases arose where it was impracticable or impossible to obtain all of the necessary stadia shots, to enable the detail of the map to be filled in, from some station on the base line run as previously outlined. In such instances a stub line was run to a point that would command the area, and when the desired shots had been obtained from the stub station, the line and topography were continued ahead from the base-line station left at the time the stub was started.

ALLOWABLE ERRORS

On closing up the survey for any tier of sections, any error in chaining, azimuth or levels which had been made since the initial point was left was discovered. The following were the maximum allowable errors in the field work at any closure, basing these errors on the length of the base line run since the point closed on was established, excluding all stub lines run:

Azimuth, 1 min. per mile of base line run, with a maximum error of closure in any case of 5 min.

Latitudes and departures, 1 ft. per 4000 ft. of base line, the error of closure in feet being the square root of the sum of the squares of the errors of closure of the latitude and departure of the point closed on.

Levels, 0.05 ft. times the square root of the distance in miles of base line.

In case any of the errors of closure exceeded the above limits the work was checked over and the errors were rectified. Errors were very readily located by making ties across between any two sections in the adjacent tiers, as the tie *mn*, in the illustration. The levels were adjusted at the time the circuit was closed up on completing the survey of a tier, as at the points *A*, *B* and *F*. The levels on one end of the tiers were assumed to be correct and the elevation of the point *B* was taken as having been correctly obtained from the elevation of the point *A*. When the circuit was closed at the point *B* a correction was obtained, which was applied to the point *F* to obtain the adjusted elevation of *F*. This adjusted elevation of *F* was then used in starting the survey of tier 3. This assumed that the relative elevations of *A*, *B* and *F* were correct and that there had been a true line of levels of 2 mi. long run between the points *A* and *F*. No adjustment of the levels was made at the closures on the other end of the tiers, at the points *C* and *D*.

STADIA WORK

As previously stated, the transitman, recorder and four stadia rodmen constituted the transit party. Two rodmen worked on each side of the base line, each of the four rodmen covering a strip 450 ft. wide parallel to the base line. The outside rodman always occupied the same relative position with reference to the base line and was held responsible for his side of the line, and he must connect up his shots and remember the country as the work progressed. On turning corners the head rodman on the side of the base line with the largest area would have both assistant rodmen on his side of the line, so that the country was uniformly worked up parallel to the progress of the base line.

Similar shifts were made if one side of the line was rough country and required a greater number of shots to control than the other side. The four rodmen sawtoothed back and forth parallel to the base line, each keeping his 450-ft. strip worked up by giving shots at the breaks in slope. As each man's shot was put down in the notebook the recorder put the rodman's initial in the notes for future reference.

The stadia rods used were 13 ft. long and 5 in. wide, the graduations being black on a white background. Symbols were used for the even foot marks and a sawtooth figure 3 in. long extended from one edge of the board toward the center at every 0.2-ft. division.

When the stadia rodmen had covered the ground half way between the transit point and the one ahead, the transitman moved up. If the transitman had not by this time got his foresight reading from the level party on the transit point ahead, the chief of party put in a 60-d. nail for a hub and one of the stadia rodmen moved up and gave the transitman his foresight, reading on the nail hub. The station number and elevation of the hub was determined later when the level party caught up.

The recorder carried a bundle of backsights made from a common whole lath with a red-and-white (or black) flag tacked on the top about 8 in. wide and 1 ft. long. On leaving a transit point the recorder put up one of these flags for a backsight. These flags scattered around over the country gave the rodmen and all party members information in regard to direction and location. No stadia was read on any of the Government corners, but chained angle ties were made for the purpose of their location. It was the intention to have the absolute correct latitude and departure of each corner an integral part of the horizontal primary control.

The transitman and assistant draftsman were held responsible for the correct reduction of the base-line traverse notes and the computation of the summation of latitudes and departures. The day's notes were reduced each night so that they could be turned over to the draftsman the next morning and be ready for plotting. Similarly after supper each evening it was the recorder's duty, with the assistance of the four stadia rodmen, to reduce the stadia notes taken during the day and see that these notes were ready for use by the draftsman the next day. A 20-in. stadia slide rule was used for the reduction of the stadia notes.

The levelman, as previously stated, ordinarily had two assistants—a rodman, who was also head chainman, and a stakeman, who was also rear chainman. These two chainmen measured the horizontal distance between transit points. The head chainman, using his level rod as a picket, gave the levelman the profile readings at every station on the base line, and oftener where breaks in the profile occurred. The rear chainman carried a few stakes and a hand axe. On chaining up to the head flag, a hub was put in and tacked and referenced by a guard stake properly marked with the station number on the outside and the elevation on the inside of the guard stake.

THE MAPS

The original detail topographic maps were plotted with a tier on one sheet, each of the sections which were a part of the same tier appearing on the same sheet of detail paper. When the maps were traced only one section was traced on one sheet. On no tracing of the topographic maps did portions of two different sections appear.

For filling in the secondary control of the map a 12-in. paper protractor was used, with a scale of distances laid off on the diameter. All of the section corners were located on the map, for each section corner a complete description of the existing corner found was noted, and in case the corner was not found and established such fact was noted on the map. The actual acreage of each section was shown, obtained by computation based on the location of the existing corners found and lost corners restored. The elevations of all shots, profile as well as stadia shots, were traced on the section map, and a true meridian obtained from the bearing of the base line appearing on the sheet in question, was shown. The detail maps were completed in the field office, but the tracings of the section maps were made in the home office in the city.

RECORD OF SHOTS

Having explained in detail the results desired and the organization adopted in the field and office work, the accompanying table can be presented and the data therein will be intelligently understood and can be compared with other similar topographic surveys.

The survey of the 56,000-acre tract was made during the months of April-July, 1909, and the data presented in the above table were obtained from the original field books. The time, June 1, was selected because this was approximately the middle of the survey, and for this reason the notes for the ten-day period chosen do not represent either the maximum or minimum efficiency of the party. The time spent in the field on actual survey work was in excess of 8 hr.; on the average, about 1½ hr. were required for the drives to and from the work.

From this table it will be noted that the best day's run was on June 12, and that on this day the transitman, with four stadia rodmen, took 560 stadia readings. These readings were put down by the recorder, the transitman keeping no notes. This particular transitman was as rapid, accurate and efficient a man with an instrument as the writer has ever seen, and like all good instrument men he used either eye for

TOPOGRAPHIC SURVEY DATA

Date—Weather	Length of base line, ft.	Number transit set-ups	Number stadia readings	Number rodmen	Readings per rodman	Readings per acre	Acreage covered
May 28, cloudy and warm..........	16,785	13	446	3	149	0.80	560
May 29, clear and warm...........	19,065	10	506	3	169	0.82	620
May 30, Sunday.							
May 31, party on other engineering work.							
*June 1, cool and rains.............	8,250	4	216	3	72	0.83	260
June 2, cloudy and showers.........	18,700	13	429	4	107	0.67	640
June 3, clear and hot..............	20,100	13	496	4	124	0.73	675
June 4, clear and hot..............	18,600	12	470	4	118	0.78	600
June 5-8, moved camp and party on other engineering work.							
June 9, clear and hot; showers.....	23,407	15	394	4	99	0.51	780
June 10, cloudy and hot...........	19,218	12	444	4	111	0.67	660
June 11, clear and warm...........	21,000	12	493	4	123	0.70	700
June 12, clear and warm...........	25,000	13	560	4	140	0.66	850
June 13, clear and warm...........	22,375	14	489	4	122	0.66	740
Totals excluding June 1........	204,250	127	4,727	38	1,262	7.00	6,820
Average excluding June 1........	20,425	12.7	472.7	3.8	126	0.70	682

*Rain 10 a. m. and all afternoon.

sighting and taking his readings. While he was taking stadia readings at a station there was practically no cessation in his delivery of the readings to the recorder. It will also be noted from the table that when only three rodmen were in the field each rodman gave more shots, and that these shots were closer together than when four rodmen were in the field. This shows, as was proved by actual experience in the field, that four rodmen were needed to obtain the maximum efficiency of output from the transitman.

COSTS

Complete cost data were kept of the topographic survey, and the actual cost of the work, including salaries and expenses, was as follows:

Class of work	Unit cost per acre
Field topography	$0.077
Plotting topography	.025
Tracing section maps	.019
Total cost per acre	$0.121

The writer has always felt that he had established a record of speed and efficiency, consistent with the desired results and accuracy, on topographic map work and still believes that if the details of the topographic survey where "600 transit shots in eight hours" were taken were published and a table was given showing the work accomplished, similar to the one presented herewith, the reader might intelligently form an opinion of the character of the survey and the speed, accuracy, efficiency and results obtained.

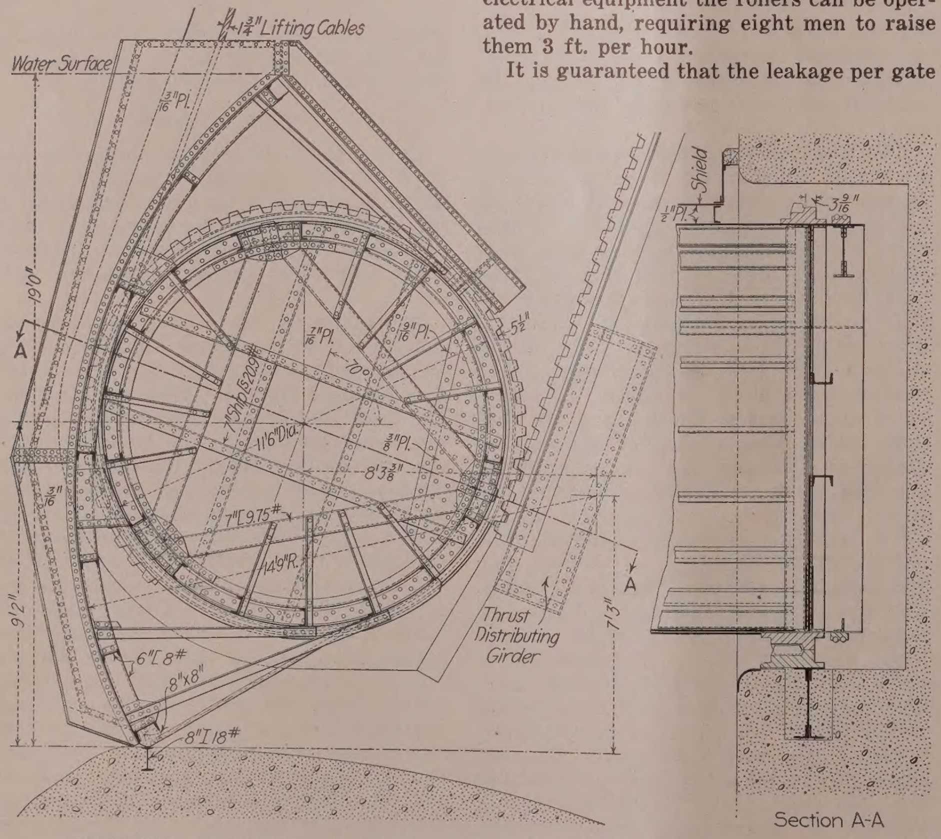
STEEL INGOTS and steel castings of all kinds produced in Canada during 1913 totalled 1,042,503 gross tons, against 853,031 tons in 1912—an increase of more than 22.2 per cent, according to a special statistical bulletin issued by the Bureau of Statistics of the American Iron and Steel Institute.

Rolling Dams for Long Lake Development

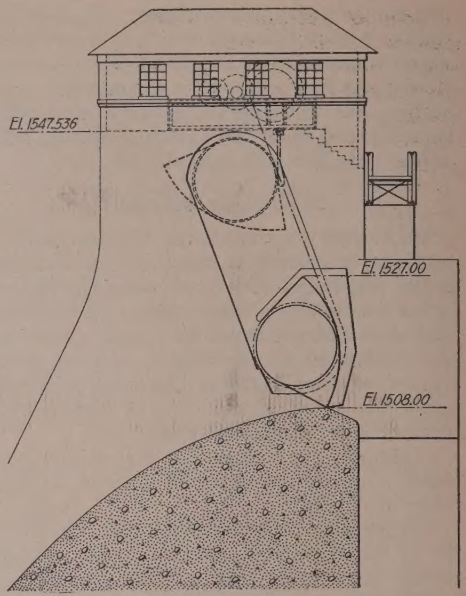
Washington Water Power Company Makes Provisions for Three 65-Foot Rollers 19 Feet High to Be Installed When Needed

THREE rolling dams, each having a clear span of 65 ft., and the group raising the water level 19 ft. above the crest of the spillway, will be installed at the dam on the Long Lake development of the Washington Water Power Company, near Spokane, Wash. As it will not be necessary to use the total head at this plant for some years, these movable parts of the dam will not be placed until that time. They have, however, been designed in detail, so that all provisions for their erection can be made when the dam is built. The rollers will be used to take care of flood waters and also, in connection with two smaller gates, serve to maintain a constant elevation of the surface in the pond throughout the entire year.

Each roller will consist of a steel cylinder 11 ft. 6 in. in diameter and 72 ft. long, having a shield 19 ft. high on its upstream side. The accompanying illustrations show details of construction of the roller, shield and water seals. The rollers will be separated by concrete piers 15 ft. wide, on top of which houses will be erected for the operating mechanism. Each pier is recessed to receive the ends of the roller, hoisting cables and racks. The operating mechanism, of which a duplicate set is placed on piers 2 and 3, consists of the usual gears and worm connected to a 6½-hp, 220-volt, three-phase motor, which allows the raising of the middle gate from either pier. Each gate is raised by a pair of 1¾-in. cables passing around the end of the roller and attached to the drum on the hoist. By referring to the section it will be noted that the rack on which the toothed rim travels is placed on an incline, the total travel being 25 ft. and requiring 1 hr. In case of accident to the electrical equipment the rollers can be operated by hand, requiring eight men to raise them 3 ft. per hour.



SECTIONAL ELEVATION AND DETAIL OF END FRAMING OF LONG LAKE ROLLERS



ARRANGEMENT OF ROLLERS ON SPILLWAY

It is guaranteed that the leakage per gate will not exceed 1 sec.-ft. This remarkable tightness is secured by means of water seals, which consist of an oak timber placed on the lower end of the shield and resting on an I-beam embedded in the concrete. At the ends steel diaphragms with attached 6 x 6-in. oak timbers—which, due to water pressure and flexibility of the metal, are forced against the flanges of I-beams placed in the side of the piers—serve as a seal. The total weight of the three rollers with their operating mechanism will be about 740,000 lb. This type of movable dam was chosen because it gives a large unobstructed opening and because of its simplicity of construction, ease of operation and tightness of water seals.

The Washington Water Power Company, of Spokane, Wash., is a consolidation of the Spokane Street Railway, the Spokane Electric Railway Company and the Edison Electric Illuminating Company. The chief engineer is C. F. Uhden. The rollers were designed by Maschinenfabrik Augsburg-Nürnberg, of Gustavsburg, Germany.

Rapid Concrete Work on St. Louis Waterworks Tunnel

WHAT is claimed to be a record in concrete work was registered the week of Aug. 10 in connection with the lining of the St. Louis waterworks tunnel. The Fruin-Colnon Contracting Company built twelve 36-ft. sections of the 8-ft. tunnel, 18-in. thick, in six 8-hour days. In order to do this both of the two 36-ft. forms used on the work had to be moved and filled each day. The pneumatic method of concreting was used, the mixer and equipment being furnished by the Concrete Machinery & Placing Company, of Chicago. A description of this work was printed in the Engineering Record of June 27, page 736.

THE PANAMA CANAL classified expenditures from the beginning of the work to May 31, 1914, were as follows:

Department of Civil Administration	$7,110,237.93
Department of Law	60,109.73
Department of Sanitation	17,299,537.96
Department of Construction and Engineering	208,458,690.49
General items	90,330,597.25
Fortifications	6,416,884.75
Grand total	$329,676,058.11

Four-Track I-Beam and Concrete Bridge

Crossing of One Railroad Over Another Entirely Inclosed in Massive Concrete Slabs for Protection Against Gases

THE Sandusky Division of the Lake Shore & Michigan Southern Railway crosses over two tracks of the New York, Chicago & St. Louis Railroad near Vermilion, Ohio, on a four-track bridge which, with its supports, is constructed almost entirely of I-beams protected by concrete that in turn is protected from locomotive blasts by iron plates.

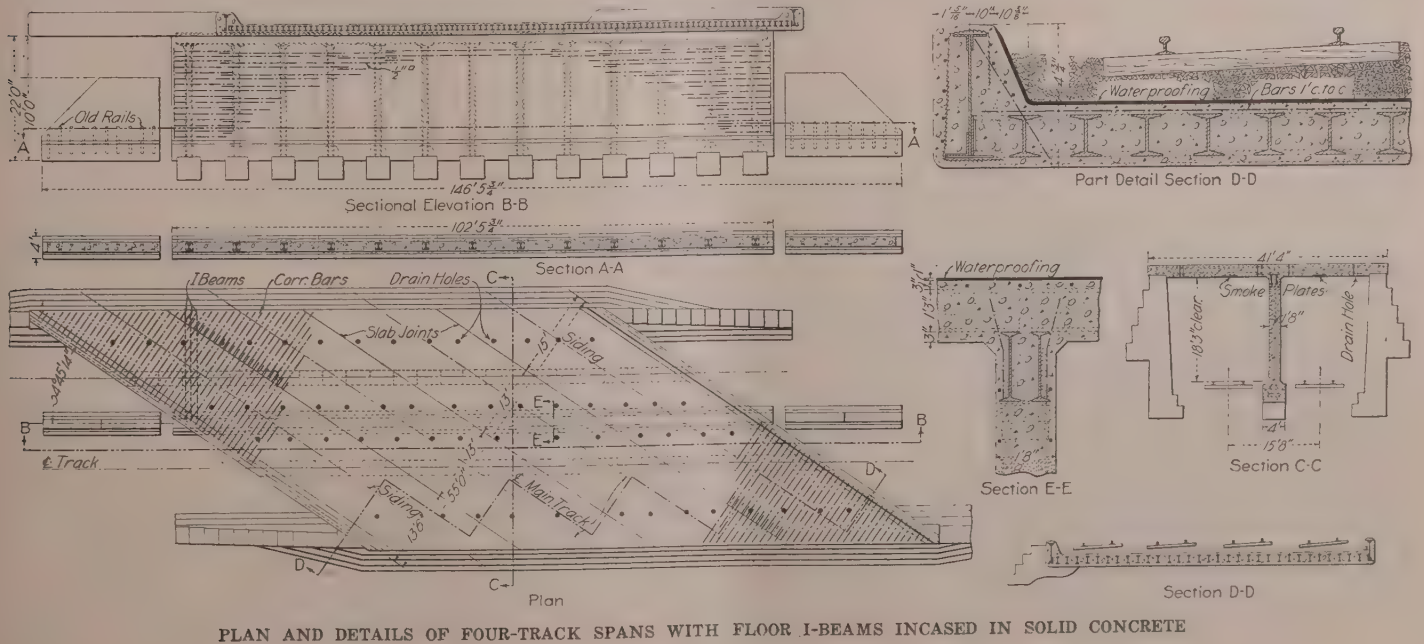
The bridge is heavily skewed and its trapezoidal platform consists of 15-in. I-beams spaced 12 in. apart perpendicular to the abutment and inclosed in a solid mass of concrete 20 in. thick. The I-beams are supported intermediately on the top flanges of a pair of 24-in. 80-lb. I-beams midway between the abutments and parallel to them, these larger beams being carried on steel columns 8 ft. apart, also entirely inclosed in a vertical wall of reinforced concrete. This wall is located on the center line between the low-grade tracks, and at each end it is protected from impact by a concrete collision bulkhead wall in the same plane. This wall is doweled to its footing by vertical rails 5 ft. long, and is inclined on the outer end to divert any moving car or train.

COLUMNS AND FLOOR SLABS

The columns have an H-shaped cross-section made of a 15-in. I-beam web and two 15-in. channels with their flanges turned in. The sides of the bridge, parallel to the overhead tracks, are finished with fascia plate girders 42 in. deep, which support the ends of some of the transverse floorbeams and serve as curbs to retain the ballast.

The concrete floor slab is continuous except for three longitudinal construction joints between the tracks. It is mixed 1:2:4 and is carried completely around the fascia girders to form solid reinforced curbs 2 ft. 2 in. high above the main surface. The upper surface is waterproofed and the under surface is protected from locomotive blasts by a full-length line of cast-iron plates 1 in. thick and 30 in. wide, flush with the surface of the concrete over the center line of each of the depressed tracks. These plates have lugs in the upper side with holes through them to receive hooks on the ends of vertical suspension rods embedded in the concrete between each pair of beams. The floor slab is drained through sixty vertical 2½-in. pipes arranged in four rows parallel to the abutments. The bridge contains 465 yd. of floor-protection concrete.

The bridge was designed and constructed under the direction of G. C. Cleveland, chief engineer, and B. R. Leffler, bridge engineer.



PLAN AND DETAILS OF FOUR-TRACK SPANS WITH FLOOR I-BEAMS INCASED IN SOLID CONCRETE

Salvage Operations on the Empress of Ireland

To Afford Direct Access Holes Large Enough to Admit a Diver Are Cut through the Submerged Plates of the Steamer

By FRANK RICHARDS
New York City

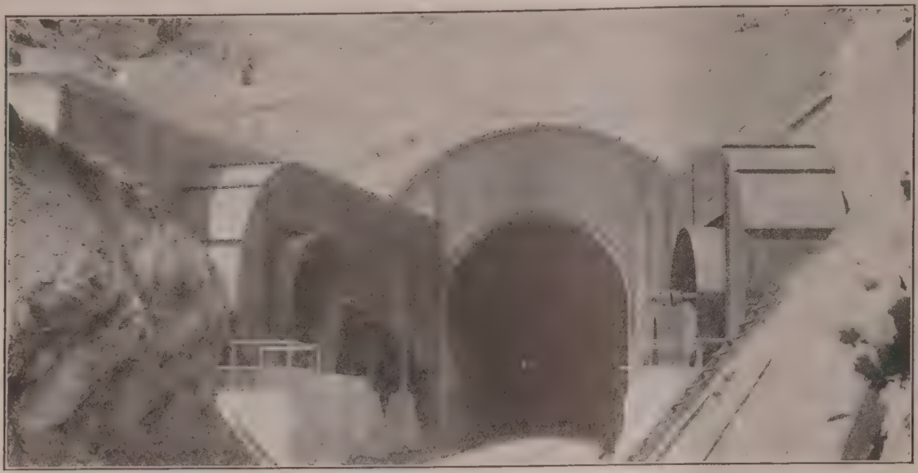
INASMUCH as it has been definitely settled that it is practically impossible to raise the great steamer Empress of Ireland so unfortunately sunk in the lower St. Lawrence, the next thing is to save whatever is possible from the wreck—all the bodies of the drowned that can be reached, the mails and the gold, of which there was a large amount.

When working in the interior of a sunken vessel the divers very properly object to following intricate passages where air pipes may be fouled and life lines cannot have a direct pull, and especially where, as in this case, the working pressure approaches the limit of endurance. One diver, by the way, has already lost his life on this work. It was determined, therefore, to cut a number of holes in the inclined side of the ship to give the men short and direct entrances to certain locations where they might expect to make the most important finds.

The general scheme was to cut a number of rectangular openings, say 4 ft. or more in dimensions, through the steel plates, giving the divers free passage through them, and four or more of these holes have thus far been cut. For each side of the rectangle a row of holes is drilled as close together as possible, defining the opening all around, and then the piece inclosed is torn out. This job is not as easy as the telling of it, the most difficult part of all, perhaps, being the drilling of the first one or two holes, on account of the difficulty of applying the necessary pressure behind the drill to make it cut. After two corner holes have been drilled, hook bolts can be inserted and these are made to support a steel beam placed at such a distance from the sheet as to form a proper backer for the drill. The work is then comparatively easy for all that row. The thin portions between the holes are not cut away by chisels or otherwise, but the sheet is torn away bodily by brute force. The surface being inclined at a considerable angle, hooks can be inserted in a number of holes at once along the bottom, and then a powerful pull from a hoisting engine on the wrecker will do the rest. In this case it is not necessary to pull the sheet entirely off; it can be swung up and let remain there like an open door.

The drill employed for this work is known as the Little David No. 2, reversible. At the depth where the drills were employed the water pressure was about 40 lb., so that this had to be provided for by additional air pressure to correspond. The air is supplied by two Rand compressors, RC, of a type now somewhat obsolete, but which have done excellent service in other places. The air for the divers is supplied by hand-operated pumps, which the divers prefer. Six divers are employed with a large gang of men for the various service required. The work of salvage is being done by King & Wotherspoon, of New York City.

A DAM on the Tandula Irrigation District in India, now in course of construction, will have a length of 16,500 ft. according to a communication from an Indian correspondent. The reservoir which will cover an area of 10,750 acres, will have a storage capacity of 233,000 acre-feet. The structure is an earth dam with a puddle cutoff trench. At the present time about one-half of it is completed. Its maximum height will be 72 ft. Another reservoir, of 200,000 acre-feet capacity and having a dam 8400 ft. long and 84 ft. high, is also in course of construction. It will serve to store water for the Mahanadi Canal, which is built for a discharge of 2000 sec.-ft.



END VIEW OF VENTILATING PLANT, SHOWING POSITION OF FANS

Ventilation of Allegheny Summit Tunnel

Successful Installation of Virginian Railway at One Portal of a 5176-Ft. Bore for the Most Part on a 1.22-Per Cent Grade

By F. F. HARRINGTON
Engineer of Structures, Virginian Railway, Norfolk, Va.

VENTILATION of Allegheny Summit tunnel on the Virginian Railway, a 5176-ft. bore, is now accomplished by a special plant, installed at one portal, consisting essentially of two large fans, one on each side of the track, which force air into a nozzle that contracts in a length of 50 ft., producing a high velocity of air through the tunnel. The plant was put into operation April 1 and has met all requirements for ordinary operating conditions.

Allegheny Summit tunnel is located on the Virginian Railway, 277.6 mi. from Norfolk, Va., between Yellow Sulphur and Merrimac, Va. Princeton, W. Va., 340 mi. from Norfolk, Va., is the assembling yard for coal mined at points west and north along the main line and on branch lines. At this point long trains are made up and sent through to tidewater. The maximum eastbound grade from Princeton to Sewalls Point, with two exceptions, is 0.2 per cent compensated for curvature, and the maximum westbound grade between the same two points, with two exceptions, is 0.6 per cent compensated. The exceptions are at Oney Gap and Allegheny Summit, located respectively 3 and 62 mi. east of Princeton. A single engine hauls eighty loaded cars of 100,000-lb. capacity from the Princeton yard to tidewater without assistance, and the same engine hauls an equal number of empty cars against westbound grades, except at the summits mentioned in the foregoing. At Allegheny Summit a single pusher engine is used between Whitethorne and Fagg, hauling eighty loaded coal cars eastbound on a maximum 0.6 per cent compensated grade from Whitethorne to the summit, a distance of 10 mi., and eighty empty coal cars westbound on a maximum 1.5 per cent compensated grade from Fagg to the summit, a distance of 7 mi.

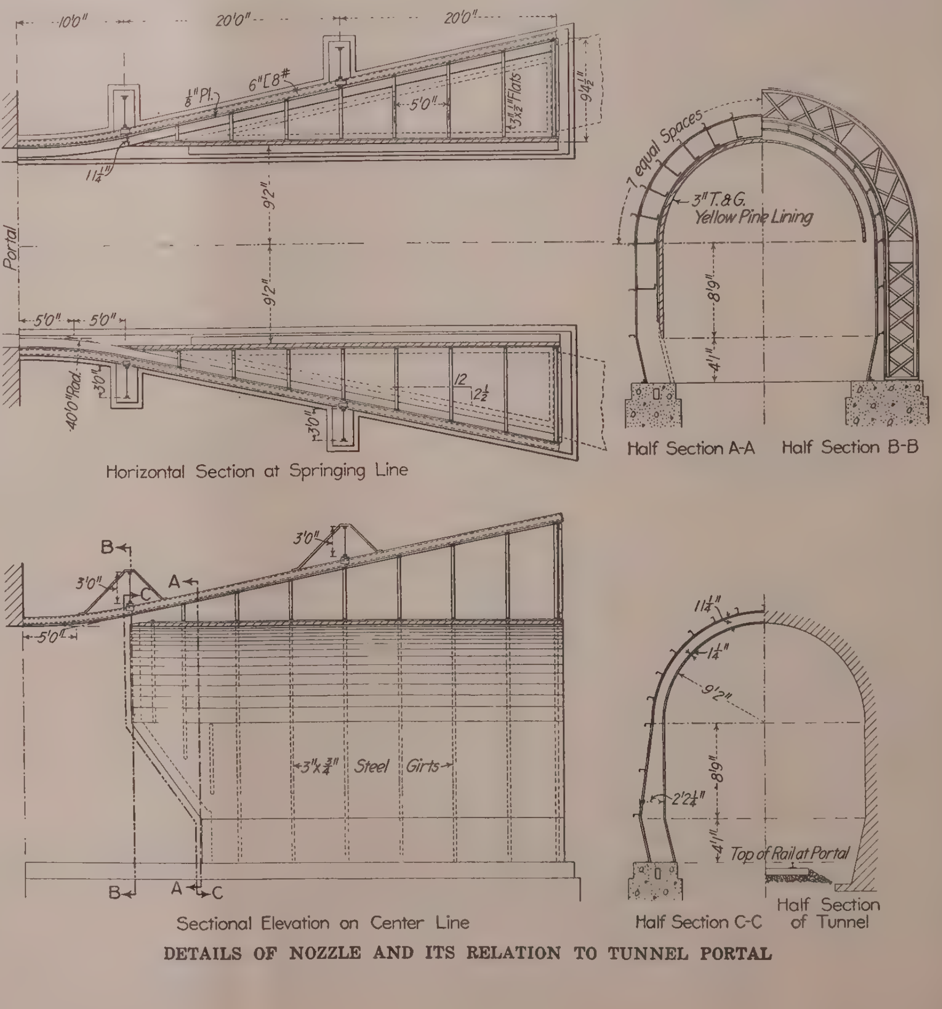
ALIGNMENT AND GRADES

The alignment of Allegheny Summit tunnel is tangent except for about 200 ft. at the east end, which is on a 2-deg. curve, and the grade is 1.22 per cent except for about 1000 ft. at the west end, which is on a vertical curve. The total length between portals is 5176 ft. and the cross-sectional area is 375 sq. ft. It was lined with timber throughout when constructed in 1908, and afterward concrete footings were constructed and two sections, 50 and 248 ft. long, were lined with concrete. The remainder of the tunnel was lined with concrete last year, and as this lining contracted the sectional area and increased the heat considerably, the ventilation of the tunnel was authorized by the management to improve the operating conditions.

The method employed for the ventilation of the tunnel is covered by patents held by Charles S. Churchill and Charles C. Wentworth, of Roanoke, Va., who furnished the general plans and specifications for the nozzle and the necessary data for obtaining bids from the fan manufacturers. The plant is located at the east end and is connected to the east portal of the tunnel. It is illustrated by the drawings and photographs. It consists briefly of two large fans operated by electric motors with Morse chain drive, one set on each side of the track, which force air through sheet-iron connections between the fans and the nozzle and then through the nozzle, where the inner opening is reduced in area in order to give a high velocity through the tunnel. The smoke and gases from the westbound engines on the ascending grade are therefore driven ahead, thus clearing the tunnel and making it cool and comfortable for the trainmen. The eastbound engines drifting on the descending grade emit little smoke and gases, and it is not necessary to operate the fans, except to clear the tunnel when desired after the passage of eastbound trains.

CAPACITY OF PLANT

The ventilating plant was designed to deliver a total volume of 590,000 cu. ft. of air per minute through the nozzle, the nozzle having an outlet area of 74 sq. ft., which is equivalent to a velocity of air in the tunnel of about 1600 ft. per minute. A thorough investigation was made as to the relative economy of operation by steam or electricity and the construction of a power plant or the purchase of power, and it was finally decided to use electric current and to purchase power from the Appalachian



DETAILS OF NOZZLE AND ITS RELATION TO TUNNEL PORTAL

SIDE VIEW OF VENTILATING PLANT AT ALLEGHENY SUMMIT TUNNEL

Power Company operating in that locality. The Appalachian Power Company was organized in 1911 for the purpose of developing the water power of the New River and distributing it by electric transmission throughout southwest Virginia and southern West Virginia. It furnishes electric power for the operation of coal mines and other industrial plants in those districts. The high-tension transmission lines operate at 88,000 volts and feed substations at various points which lower the voltage for distribution through secondary lines to the various power consumers.

A special high-tension transmission line was built from Radford, Va., to the east portal of the Allegheny Summit tunnel, where a substation was constructed which lowers the voltage to 2300 volts for the operation of the ventilating plant. The contract for electric power provides for a primary charge per kilowatt of maximum demand and a secondary charge for current consumed on a sliding scale. The maximum demand and the current consumed are determined by suitable meters, and a minimum annual charge is made regardless of the power consumption.

FANS

The fans used are of the Multivane type, manufactured by the B. F. Sturtevant Company, of Hyde Park, Mass. They have ⅞-housing, single-inlet and top-horizontal discharge. They are 116½ in. in diameter and 80¼ in. in width, and deliver through the nozzle 295,000 cu. ft. of air per minute when operating at 195 r.p.m. The motors are of the 300-hp, 3-phase, 60-cycle, 2200-volt, 514-r.p.m., slip-ring type, manufactured by the General Electric Company; they drive the fans by means of Morse silent chains, spaced 5 ft. 6 in. on centers.

The switchboard is arranged with automatic starters for operating the motors from track circuits, but the track circuits have not been installed. The object of the automatic control is to make the plant more reliable and to reduce the cost of operation. All of the control apparatus is located in the motor house on the north side of the track, and the two three-wire lead-sheathed cables are installed underground in a 6-in. conduit to the motor on the south side of the track. The motors are protected from lightning by choke coils and multigap-type lightning arresters.

The blowing nozzle is constructed of steel, except the inner lining, which is of tongue-and-groove heart longleaf yellow pine bolted to steel girts. It is made to conform to the dimensions of the tunnel where it connects to the portal, and is 50 ft. long outside of the tunnel. The inner lining is also of the same form and dimensions as the tunnel, but the outer lining, made of ⅛-in. steel plates, is enlarged in the form of a conical surface with cross-sections parallel to the inner lining from a point 5 ft. from the portal to the face of nozzle. The minimum distance between the inner and outer linings at a point 10 ft. from the portal is 11¼ in., and the area of the contracted opening is 74 sq. ft., measured on the projection at right angles to the axis of tunnel. The front of the nozzle is provided with openings to which the air ducts from the fan housings are connected. The nozzle is thoroughly braced and is airtight. It was manufactured and erected by the Roanoke Bridge Company, of Roanoke, Va.

The air ducts between the fan housing and the nozzle are made of ⅛-in. sheet steel and are braced with angle irons. Particular attention was given to the construction of these ducts and the fan housing in order to prevent excessive vibration from the operation of the fans.

FOUNDATIONS

The foundations for the ventilating plant are of concrete and the motor houses are of reinforced concrete and brick. To save expense, the floors of the motor houses were placed about 8 ft. above the top of the rail. Concrete stairways and lookout platforms are provided for the convenience of the operator. To provide room for the switchboard for both motors, the motor house on the north side of the track was built larger than that on south side. The foundations and motor houses were constructed in accordance with plans furnished by the railway company.

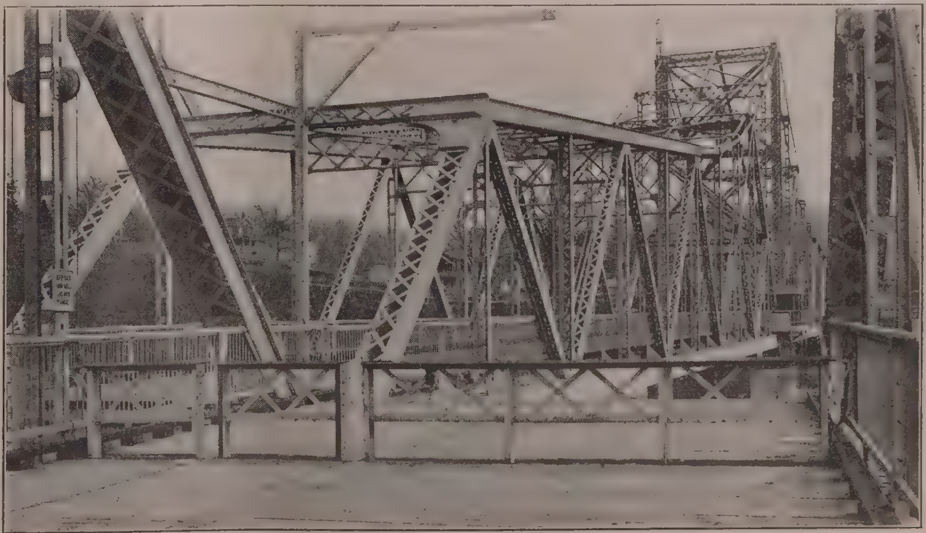
When the ventilating plant was put into operation April 1 anemometer tests were made which showed an average air velocity in excess of the contract requirements and actual power consumed of about 600 hp. Train tests indicated that a speed of from 14 to 15 mi. per hour could be attained with the smoke driven ahead of the engines, thus giving good ventilation in the tunnel under ordinary operating conditions. A bulletin has, therefore, been issued to limit the speed of westbound trains to 14 mi. per hour, and at this rate the regular freight trains will not be required to slow down in going through the tunnel. The fans operate only for westbound trains, and the time of running is ordinarily less than 10 min. A train-dispatcher's telephone is installed in the motor house to enable the operator to keep in touch with the train movements in both directions and to communicate with the Appalachian Power Company at Bluefield, through the dispatcher's office at Princeton, in case of current failure or for any other reason. The total cost of the ventilating plant was about $30,000 complete.

East Haddam Bridge Safety Gates

Vertically Moving Steel Trusses Installed at Drawspan, Designed to Resist Heavy Impact from Automobiles

TRAFFIC across the swingspan of the East Haddam bridge over the Connecticut River a few miles above Hartford is protected by special safety gates designed to present an efficient physical barrier to automobile traffic instead of merely a visual one, which is often about all that the light swinging gates generally installed afford.

With this end in view the designer of the bridge at first considered the construction of horizontally swinging gates. These, however, did not lend themselves to satisfactory detailing. Eventually the vertical I-beam stop that had been applied to car tracks over swing bridges suggested the idea of substantial gates rigidly connected to strong vertical posts that could be raised and lowered, and would present consider-



SAFETY GATES RAISED TO STOP TRAFFIC—DRAW SPAN PARTLY OPEN able resistance to displacement. Gates of this type, which were described in the Engineering Record of Nov. 30, 1912, page 615, were installed some time ago and have proved very satisfactory for a service of 15,000 autos per year crossing the drawspan, which is swung about 2000 times per year.

In order to clear the track rails the gates are made in three sections. Each section consists of a horizontal lattice girder attached to two or four vertical 7-in. channels which extend below the lower flange of the girder and at one end of the drawspan have clearance between the webs of a double floorbeam. The top flanges of the girder have thick horizontal cast-iron checkered plates 16 in. wide, which carry the traffic over the floor opening when the gates are lowered and the drawspan is in service. At each end of the bridge a 2-hp motor controlled from the operator's house on the drawspan drives a transverse shaft with pinions engaging vertical racks on the gate posts, which are raised or lowered 38 in. in 8 sec. The gates are balanced by cast-iron counterweights suspended from wire ropes and guided from the outer flanges of the vertical posts in the trusses.

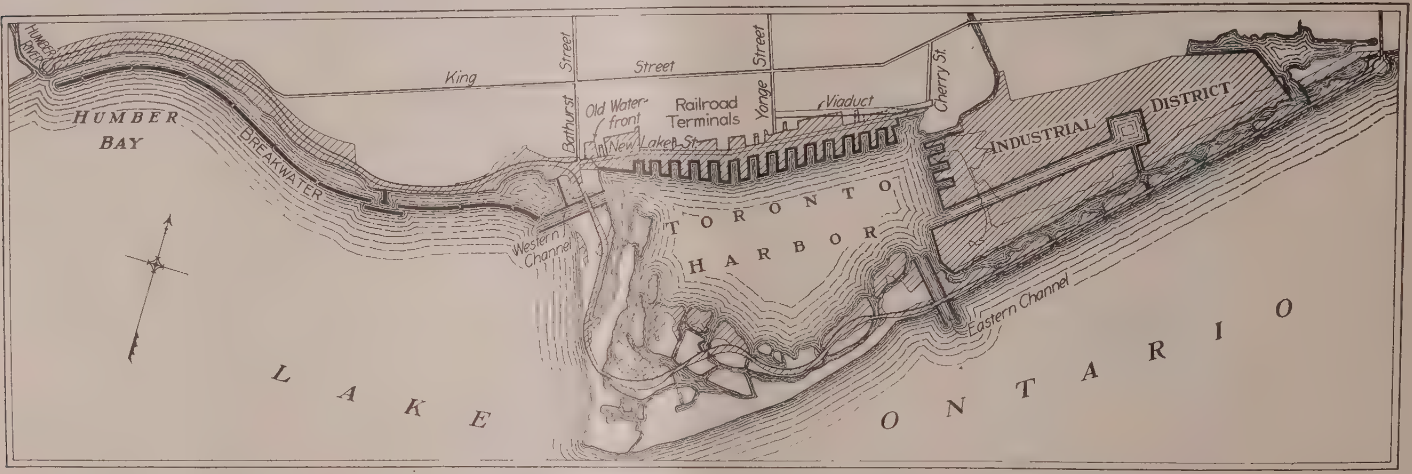
When the gates are raised their vertical posts have bearings about 30 in. between the floorbeam webs at one end of the draw and in masonry wells on the approach at the other end, and are believed to be so strong that the force required to shear them off or to bend them over and allow an automobile to pass would be adequate to stop the automobile. The gates are set back 15 or 20 ft. from the draw opening and thus provide a safety zone beyond the barrier. The gates are usually closed before the draw is swung; but since they are not interlocked with the operating machinery, they can, in case of emergency, be very quickly operated independently of the draw machinery.

The bridge was designed by Boller, Hodge & Baird, of New York City, engineers of the superstructure, and E. W. Bush, chief engineer of the East Haddam and Haddam Bridge Commission.

GOVERNOR GOETHALS of Panama approved a recommendation to close the Empire District Sept. 1 or as near thereafter as possible, according to the "Canal Record." The offices of the accounting department are now located in the new administration building at Balboa Heights.

Toronto Harbor Improvements Are Most Comprehensive on American Continent

The $25,000,000 Scheme Now Under Way Embraces the Creation of an Industrial District and the Building of New Docks and a Waterfront Boulevard 14 Miles Long



GENERAL MAP OF THE TORONTO WATERFRONT, THE CROSS-HATCHED AREAS INDICATING MADE GROUND

TORONTO early this year began work on a $25,000,000 harbor development plan, which, for comprehensiveness, is not even remotely approached by anything under way on this continent. It includes not only new facilities for shipping, but also the creation, on made land, of a new industrial district and the development of a park scheme, consisting of a boulevard and waterways for pleasure craft, extending over a distance of 14 mi.

Justification for so large a program is found in the aggressiveness and growth of the city itself and in the anticipated commerce from the enlarged Welland Canal, a work on which the Canadian Government is now spending $50,000,000. Moreover, the Government has shown its faith in the soundness of Toronto's plans by building part of the works with Dominion funds.

One element in the situation is worthy of especial mention, for, lacking it, the scheme probably could not be carried out. Toronto owns all but 15 per cent of its entire waterfront. Private interests, therefore, are not in a position to block a comprehensive development. The scheme is being worked out under the general direction of the Toronto Harbor Commission, a board of five serving without pay, to whom the city deeded its waterfront holdings and its right to the shallows and marsh which are to be filled in. The commissioners are vested by Dominion charter with broad powers in the improvement and management of the harbor and waterfront.

EXTENT OF SCHEME

The extent of the scheme is shown on the plan herewith. From the eastern end of the harbor westward to the eastern ship channel a sea wall will be built, while from the western ship channel to the mouth of the Humber River a breakwater will be constructed at a distance varying from 500 to 900 ft. from the present shore line. Back of the sea wall will be a boulevard, park and lagoon, while to the west a similar boulevard and park-development scheme will be carried out, bordering the lagoon formed by the breakwater. Connecting the two sections will be a boulevard link, winding back and forth over the islands.

The second large feature of the development will be the Toronto Harbor Industrial District—an area of 881 acres reclaimed by filling in shallow water. When completed it will afford no less than 646 acres for factory sites. The remaining area, 235 acres, will be occupied by streets and railroad tracks.

The third feature of the plan consists of the new set of docks, shown in the drawing, replacing the present piers, which are rapidly becoming inadequate for the city's water-borne commerce. This part of the scheme will involve considerable land filling and the creation of a new thoroughfare along the harbor. Closely allied to the scheme, in that it will play a large part in the city's development, though not a part of the Toronto Harbor Commission's work, is the rearrangement of the city's railroad terminals. Designs for a new station have been accepted by all the roads and construction is about to start on an adequate union passenger station. Jointly with this work the tracks east of the present station, and as far as Cherry Street, will be removed from their present grade and right-of-way and placed on a viaduct to the south, as indicated in the plan.

STATUS OF CONSTRUCTION

Of this work contract has been let by the Dominion Government for the sea wall at the east end, the breakwater at the west, the ship channel and turning basin in the industrial district, and for the marginal walls lining the waterways last mentioned. This contract totals approximately $5,400,000 and has been let to the Canadian Stewart Company, the Canadian branch of James Stewart & Company, of New York.

The harbor commissioners have let the contract for filling in the shallows to create the industrial district. This will be done hydraulically with sand taken from the harbor and from the open lake opposite the location of the district in question. This contract will run to about $6,000,000, and calls for the placing of 31,000,000 cu. yd. of material. Like the Government's contract, it has been let to the Canadian Stewart Company.

The estimated cost of the total development, excepting the new docks, is $19,000,000. The docks will add from $5,000,000 to $6,000,000 more. The sea wall, breakwater and filling work is expected to be finished well within five years, and the entire project, exclusive of the docks, in eight years. Time for beginning the dock development has not yet been fixed. Its progress is to be governed by the demand for facilities.

The work has been divided into three sections—the eastern, lying east of the Eastern Channel; the central, lying between the two channels, and the western, lying west of the Western Channel. The harbor at the east end is defined on the south by a low bar, parts of which are submerged in times of high water. The sea wall will be placed approximately 700 ft. beyond this bar along the entire front, a distance of 4.3 mi. All of the area between this wall and the shore, excepting the waterways indicated, will be filled in to an elevation of 8 ft. above mean water level. The industrial area will lie north of a line drawn 1000 ft. back from the sea wall, the intervening space of 1000 ft. being devoted to park purposes. A strip more than 3 mi. long on the north of the park area is to be reserved as a location for summer homes. The boulevard section has a width of 200 ft., immediately back of the sea wall. Besides a 50-ft. driveway, there will be a bridle path, walks and parked areas.

INDUSTRIAL DISTRICT

The industrial district will have unusually good railway facilities for connections will be made from the start to three transcontinental systems. The streets will have minimum widths of 75 and maximum widths of 175 ft. There will be tracks in alternate streets only, three tracks in each, so that there will be no disturbance of a car placed for one shipper in order to place or remove one for another.

A 400-ft. ship channel will be constructed into the district for a distance of 6800 ft., terminating in a turning basin 1000 ft. square. The sides of the channel and the turning basin will afford 3½ mi. of dockage accommodations. The depth will be 24 ft. at the start, with provision for deepening to 30 ft. in the future. The western end of this section, facing the harbor, will also be developed for dock purposes, adding ultimately 2 mi. of dockage.

Land in the industrial district is not to be sold, but is to be leased to the industries by the harbor commissioners. The rates are to be so based that dockage and interswitching will be provided without additional charge. The development in many respects will be similar to that of the Bush Terminal Company in Brooklyn, the chief difference being that the project will be a public, not a private one. Within a certain district—along the marginal way—the commissioners propose erecting the buildings.

Work in the central section consists of the dock development previously alluded to, the reclamation of 352 acres of park land on the islands, the improvement of certain sections now unsightly, and the development of the lagoons and of a 17-acre industrial section at the foot of Bathurst Street.

Work is already in progress on the last-mentioned part of the project. A dock will be provided here, back of which will be a storage warehouse and a factory building, erected by the commissioners, in which space will be rented to small manufacturing concerns.

The western section will be developed solely for park and recreation purposes. The breakwater will not only protect the shore from storms, which in the past have damaged it materially, but also create a sheltered waterway, 500 ft. wide on the average, for small craft. In all, 190 acres of new land will be made in this section.

The engineering work, under the harbor commissioners, is being carried out under the direction of E. L. Cousins, chief engineer. J. R. Wainwright is assistant chief engineer and David Molitor, designing engineer.

Resurfacing One Mile of Detroit Road with Old Material

How A Penetration Asphalt Surface Was Torn Up on Woodward Avenue, Livened, and Relaid as Asphaltic Concrete

UTILIZING the material already in a road for patch repair work is of common enough occurrence, but it is seldom that an entire stretch of road is made anew in such a manner. An example of this type of work is to be found on Woodward Avenue, Detroit, between mile posts 8 and 9, where a penetration asphalt pavement 16 ft. wide was torn up and a slight amount of asphalt and new stone added to liven it, and then relaid as asphaltic concrete.

At the outset of the work the surface coat was taken off one end of the road for a distance of about 250 ft., and two ½-yd. Rapid mixers were placed at the end of this cleared stretch. Surface material was then being taken from the road to the rear of the mixers, and after having fresh material added it was laid on the 250-ft. stretch directly ahead of the mixers. By the time the latter stretch was completed the stretch behind the mixer would be stripped of surfacing for a distance of approximately 250 ft. and the mixers could then be moved back and the process repeated. About a fourth part of ½ to ¾-in. new stone, free from dust, together with 0.4 gal. of asphalt per square yard, was added to give new life to the old material which was taken up from the road. The squeegee coat had 1 gal. of asphalt per yard, and over this was spread a coat of ¼-in. stone chips.

It took thirty-eight men twenty-one working days to tear up 9100 sq. yd. of surfacing and re-lay as an asphaltic concrete surface to a depth of 2½ in. The maximum amount laid in a 10-hr. day was 505 sq. yd. In tearing up the old surface it was broken up at two points to facilitate the speed of the work. The old material broke easily in the morning, but toward noon softened and a longer time was required in breaking. In order to save time in the mixer three men were used in breaking up the large pieces of surface material taken out of the old pavement. About 7 to 8 min. were taken for each batch; this included both loading and discharging the mix.

The equipment consisted of the two ½-yd. Rapid mixers, one Tidewater kettle, one 5-ton Iroquois tandem roller and 2 specially designed high-wheeled carts holding 7 to 8 cu. ft. of material.

The labor consisted of a kettleman, a rollerman, an engineer and a fireman (for the two mixers), two platform men, four men for taking material from the machines (two for loading and two for wheeling), six men for wheeling old material to the mixers, fifteen men for picking and loading old material, three men for fixing grades and one man on the roller, three squeegee men, a waterboy and a night watchman. A State inspector was kept on the work at all times, and it was his duty, besides inspecting the work, to take up samples of the surfacing being laid and to send them to the chemist for analysis.

The road was laid by contract in 1912 with a penetration asphalt surface, but owing to what is claimed to be poor workmanship the asphaltic penetration was extremely uneven—too much fine material being used, and the surface varied from 1 to 6 in. in depth. The road is subjected to an extremely heavy traffic. About 2300 vehicles were counted traversing it in a typical day's traffic.

The road was opened an hour after completion. The work was done under the supervision of State Highway Commissioner Frank F. Rogers by the Rapid Mixer Company, of Grand Rapids, Mich. H. B. Pullar & Company, of Detroit, were the chemists.

VARIOUS STAGES IN LAYING ASPHALTIC SURFACE ON DETROIT ROAD

Convention of New England Waterworks Association

Abstract of Some of the Committee Reports and Technical Papers Presented at the Thirty-third Annual Meeting in Boston, September 9 to 11 — Final Report on Yield of Drainage Areas and Preliminary Reports on Statistics of Water Purification and Meter Rates

(The complete papers will appear in the "Journal" of the New England Waterworks Association)

Yield of Drainage Areas

Committee Report by Frederic P. Stearns, Chairman, Giving Final Results of Extensive Studies of Rainfall and Runoff

APPOINTED in February, 1911, the committee on yield of drainage areas, consisting of Frederic P. Stearns, chairman, H. K. Barrows, George A. Carpenter, Charles E. Chandler, X. H. Goodnough, Richard A. Hale, E. E. Lochridge, Leonard Metcalf, Arthur T. Safford and James L. Tighe, has submitted its final report. So exhaustive is the committee's treatment of the subject that it is impracticable to present here anything more than a summary of the document.

SUMMARY

The committee was appointed on account of the low flow of the streams during the years 1908, 1909 and 1910. The year 1911 proved to be even drier than the preceding years, and 1912 and 1913 nearly as dry. Until the recent dry period, that from 1879 to 1884 was the driest on record. The recent period has been drier in the greater part of New England, but not as dry in eastern New York. Judging from rainfall records still drier periods occurred prior to 1850.

YIELD DEFINED

In the case of a drainage area on which there are no storage reservoirs or ponds, the yield of a drainage area means the quantity of water flowing in the stream at the lower end of the area. When a storage reservoir has been built upon the stream and the discharge is measured at the dam, the yield of a drainage area, as water-works records are usually kept, means the quantity of water discharged at the dam, corrected by adding or subtracting respectively the quantity of water drawn from or added to storage. It is therefore approximately the natural flow of the stream, but not exactly, because there is a loss of water by evaporation from the surface of the reservoir, which is not measured.

In the case of rivers like the Merrimac and Connecticut, where it is not feasible to make corrections for the amount of water drawn from or added to storage, the yield of a drainage area, as usually recorded, does not mean the natural flow of the stream, but the natural flow increased by water drawn from storage in the dry season and decreased by the water added to storage when the reservoirs are filling.

When there is a reservoir at the lower end of a drainage area, there is sometimes added an unmeasured loss due to leakage past the dam, and there may be storage of which no account is taken, as, for instance, that in the interstices of the ground around the reservoirs and in small reservoirs not under water-works control.

When there are large water surfaces the evaporation is an important item, and the yield of one drainage area should not be deduced from that of another without taking account of this element. The yield of a water surface is the difference between the precipitation upon and the evaporation from such surface, multiplied by its area. In the summer, when the evaporation is high, the evaporation is nearly always greater than the precipitation, while in the cold weather the reverse is true. The measurements of the yield of a drainage area necessarily include the combined yield of land and water surfaces, but it is feasible to estimate the yield of water surfaces with a fair degree of accuracy, and when such yield is deducted from the total yield of a drainage area, the remainder is the yield of the land surface. A much better comparison of the yield of different drainage areas can be made when the yield of land surfaces only is used.

Swamps are generally covered with water during a part of the year and are damp at other times, so that as regards evaporation they are intermediate between water surfaces and ordinary land surfaces. It has been assumed, for the purposes of this report, that 40 per cent of the area of undrained swamps and 30 per cent of the area of drained swamps should be classed as water surface, and the remainder as land surface.

PRECIPITATION AND YIELD

The water flowing from a drainage area has its origin, under nearly all circumstances, in the precipitation upon the area, and that part of the precipitation which is not evaporated, except for the small quantity of water absorbed by vegetation, finds its way into the streams. The precipitation in this section of the country is reasonably uniform throughout the year, but the evaporation which increases with the temperature varies greatly, being about six times as much in midsummer as in winter. Hence, a very much larger part of the precipitation is lost by evaporation from land surfaces in the warm than in the cold months. During the four years, 1908-1911, the percentage of the precipitation not evaporated, and consequently finding its way into the streams, was as follows:

	Per cent
December to April, inclusive	70.3
May, June and November	46.0
July to October, inclusive	15.9

In years when the precipitation is large the percentage running off is greater than in years when it is small, because the evaporation from land surfaces does not increase at the same rate as the precipitation. As a result of many comparisons it was found that when the precipitation increased from 39.29 to 56.29 in. annually the percentage running off increased from 43.1 to 53.3. To express the relation in another way, 77 per cent of the above increase in precipitation was represented by the runoff in the streams.

These figures are based on the maximum and minimum precipitation on several drainage areas during a long series of years. If comparisons were to be made between the low and high precipitation during a series of comparatively dry years, as, for instance, between annual precipitations of 35 and 40 in., or 40 and 45 in., less than 77 per cent of the difference in precipitation would be represented by the runoff. It has been assumed somewhat arbitrarily that in these cases the percentages would be, respectively, 65 and 70.

ELEVATION IMPORTANT

Other things being equal, the precipitation and consequently the yield of a drainage area increases with the elevation above the sea. The lowest records of yield received are those of low-lying drainage areas near the coast, and the highest yield recorded is of drainage areas at a high elevation in the Catskill Mountains. Observations on the top of Mt. Washington from 1876 to 1886 gave an average precipitation of 90.13 in., while the averages for the Sudbury and Cochituate watersheds for the same period were respectively 44.02 and 42.59 in.

The principal aim of the report is to furnish tables and diagrams based upon trustworthy information to facilitate computations of the safe capacity of sources of water supply. In order to use these tables, it is necessary to have: 1, The drainage area in square miles; 2, the area of water surfaces when the reservoirs are full, in square miles; 3, the available capacity of the storage reservoir, in million gallons.

In computing the tables, the area of water surfaces in most instances included 40 per cent of the area of undrained swamps, and 30 per cent of the area of drained swamps, and in applying the tables in such cases it is desirable that the area of water surfaces should include these percentages of the swamps on the drainage areas under consideration, if the most accurate results are desired.

The tables give results which vary widely, but they show what the safe capacity of proposed sources would be on the basis of the conditions which actually existed upon the drainage areas upon which the tables were based. With such wide differences in results, good judgment and a complete knowledge of the facts upon which the tables are based are necessary in order to determine intelligently the probable safe capacity of any given source.

Tables give the minimum flow of streams for short periods of from one week to three months. The results vary widely and indicate that one should be very conservative in fixing the safe capacity of a source where there is little or no storage capacity.

Statistics of Water Purification Plants

Committee Report by George C. Whipple, Chairman, Dealing with First Two of Five Topics to Be Considered—Descriptive Data and Statistics of Analysis

THE committee on statistics of water purification plants—George C. Whipple, chairman, Robert Spurr Weston, Francis D. West, Frank W. Green and E. E. Lochridge—was appointed Oct. 8, 1913, and this is its first progress report:

DESCRIPTIVE DATA

For preparing descriptions of filter plants for publication, the following schedule of desirable data has been prepared: 1, City or town, and population at last census; 2, name of owner; 3, name of designer; 4, date when plant was put into service; 5, total cost, with statement as to what is included; 6, source of supply; 7, rated capacity; 8, method of purification; 9, total capacity of subsiding or coagulating basins; 10, total capacity of filtered water basin; 11, what chemicals are used; 12, where chemicals are applied; 13, how applications of chemicals are made; 14, number of filter units; 15, net area of filter surface; 16, depths of filtering materials; 17, sizes of filtering materials; 18, for slow filters—arrangements for cleaning sand surface, sand handling, sand washing; 19, for mechanical filters—method of cleaning filter beds; 20, number of subsiding or coagulating basins; 21, how the rate of filtration is controlled.

STATISTICS OF ANALYSIS

Through the efforts of the American Public Health Association, the methods of water analysis used in North America are now on a fairly uniform basis. The practice of expressing the results of chemical analysis in parts per million is almost universal and the methods employed are coming more and more into agreement.

Blanks have been prepared illustrating the committee's recommendations regarding the form of report, the tests to be made, and the method of expressing the results. These blanks cover the following: Chemical and microscopical character of raw water; turbidity and color of raw water; bacteria in raw water; chemical character of water delivered to mains; turbidity and color of water delivered to mains; numbers of bacteria in water delivered to mains; numbers of B. coli in water delivered to mains. All of the data are arranged to show the analytical data by months and years.

The elimination of unnecessary analytical work is a matter that needs consideration. The determination of nitrogen in the usual forms of free and albuminoid ammonia, nitrites, and nitrates serves no particular purpose.

GRADES OF SUPERVISION

One step in making an analysis of water has never received half the attention that it deserves, namely, sampling. It seems desirable to establish certain grades of control of operation, based upon the character of the records kept, as follows:

First Grade: Those where analyses of the filtered water are made one or more times a day, and where engineering and such other data regarding the operation of the plant as are necessary are collected by one or more attendants constantly employed.

Second Grade: Those where analyses are made regularly, say once a week or once a month, by a trained analyst, and where an attendant constantly on duty makes simple daily tests.

Third Grade: Those where analyses are made irregularly and infrequently, and where no daily tests are made by the attendant.

EFFICIENCY OF OPERATION

No provision has been made for recording the percentage removal of bacteria, a method that has been much used in the past. Although this method has certain advantages, it is so susceptible to misuse that the committee recommends that it be omitted from official reports of filter operation.

Meter Rates

Committee Report by Allen Hazen, Chairman, Recommending Standard Form of Schedule and Sliding Scale with Three Divisions

IN the report of the committee on meter rates—Allen Hazen, chairman; Charles R. Bettes, A. E. Blackmer, A. W. Cuddeback, James L. Tighe and Philander Betts—a standard form of schedule and a sliding scale with only three divisions are proposed. This report is not final and will be open for discussion at a later meeting of the association. An abstract follows:

DIVISIONS OF SLIDING SCALE

It is proposed to make only three divisions of the sliding scale. The committee proposed that all water up to 300,000 gal. per annum (equal to 822 gal. per day, or to 40,000 cu. ft. per annum, or 10,000 cu. ft. per quarter) shall be charged for at the first or highest rate, called the domestic rate. The second or intermediate rate will apply to quantities in excess of 300,000 gal. per annum up to 3,000,000 gal. per annum. The third and lowest rate will be called the manufacturing rate and will apply to all water in excess of 3,000,000 gal. per annum from any service (equal to 8220 gal. per day, or to 400,000 cu. ft. per annum, or 100,000 cu. ft. per quarter).

It is recommended that the price per 1000 gal. or per 100 cu. ft. be an even number of cents, omitting fractions, and that the intermediate price for water be to the nearest cent midway between the average and the mean proportional of the domestic rate and the manufacturing rate.

Where the price for manufacturing water is 75 per cent or more of the domestic rate, it is suggested that the intermediate rate may be omitted and that the manufacturing rate then apply also to the water that would otherwise be sold at the intermediate rate. If the rate for manufacturing water is 100 per cent of the domestic rate, both limits disappear and one flat rate will apply to all quantities.

SERVICE CHARGE

It is essential to make a substantial service charge in order to secure equitable rates for all. The committee suggests that the procedure in determining the amount of the service charge be as follows:

First, that the average amount of money invested by the works in the service pipe and meter be ascertained. Where the works furnish the service pipe to the curb line, and the meter, the normal cost seems to be about $25 per service. Where the taker pays for the service pipe and the works furnish the meter, the normal cost seems to be about $10 for a ⅝-in. meter in position. The committee suggests that 10 per cent of this cost be taken as the first part of the service charge—that is to say, that $2.50 per annum be used where both service and meter are paid for by the works; $1 per annum where the meter only is furnished by the works, and that this part of the charge disappear where both pipe and meter are paid for by the taker.

Second, there should be a sum per annum representing approximately the cost of reading the meters, keeping the meter records, making bills, and collecting the money. For ordinary domestic services where meters are read once a quarter, $1 per annum may be a sufficient allowance.

Third, an amount which will represent the approximate average value to the works of the water that passes a domestic meter without being registered should be allowed. The amount lost per service will range from nothing to 100 gal. per day, and occasionally to much larger quantities. Assuming an average of 50 gal. per day per service at a minimum price of 10 cents per 1000 gal., the value of water so lost amounts to $1.82 per service per annum. The committee suggests for the present the use of $2 per annum for this item. The service charge should be applied in all cases whether water is drawn or not.

ALTERNATE PROCEDURE

Where there is local objection to making a service charge (even though called meter rent), the following alternate and less desirable procedure may be used. The amount that would be a fair service charge is computed as above. This amount is divided by 60 and the result to the nearest even cent is added to the domestic rate, and this new rate (which may be called a loaded or maximum rate) is applied to the first 60,000 gal. of water per annum drawn from each service. If cubic feet are used, the amount is divided by 80, and the result to the nearest even cent is added to the domestic rates per 100 cu. ft., and the increased rate is applied to the first 8000 cu. ft. per annum used from each service. In connection therewith, a minimum rate must be established. This minimum rate may be about $3 more than the computed service charge.

FORMS OF SCHEDULE

The committee proposes the following form for a schedule for meter rates:

For each service supplied by ⅝-in. meter there shall be a charge for the service and meter per annum, of..............	$———
In addition thereto, for all water drawn there shall be charged:	
	Cents per 1000 gal.
For the first 300,000 gal. of water per annum, or any part thereof, the domestic rate of	———
For water in excess of 300,000 gal. and under 3,000,000 gal. per annum, the intermediate rate of..................	———
For water in excess of 3,000,000 gal. of water per annum, the manufacturing rate of	———

The divergence between the practice of different works in respect to bearing the cost of service pipes and meters must be taken into account in some way in order to compare properly the meter rates used in connection with them. The simplest way of doing this is to deduct 10 per cent of the average cost to the works of each service from the amount computed by the schedule for each quantity. This course is followed and the annual rates in the table are thus reduced by an amount equal to 10 per cent of the work's contribution to the cost of each service. Obviously in applying any rates deduced from these figures to a particular case, it will be necessary to add one-tenth of the corresponding contribution to the works to the cost of services in that plant.

Fifty representative reports were selected for study. In each of these more than 50 per cent of the services were metered; most but not all of the selected works were in New England. An interesting comparison may be made with a compilation of meter rates by George W. Biggs, Jr., chief engineer of the American Water Works & Guaranty Company. In Mr. Biggs' figures, no deduction is made on account of the contribution of the works toward the cost of the service and meter. Obviously an allowance must be made for this item to make the results comparable with those obtained from the fifty rates investigated by the committee. In the absence of information as to what the average contribution has been, it is assumed that it has been $12.50 per service, this being about one-half of the normal total cost per service, and a deduction of 10 per cent of this, or $1.25 per annum, has been made from the figures compiled by Mr. Biggs.

Upon trial it is found that a service charge of $3 per annum (plus 10 per cent of the cost of the service pipe and meter to the works), a domestic rate of 21 cents per 1000 gal., an intermediate rate of 16 cents and a manufacturing rate of 11 cents, produce amounts which fall between the two sets of data above mentioned for nearly all quantities and correspond well with both of them. These rates may thus be taken as representing in a general way, and with a fair degree of accuracy, the present average American practice in meter rates. The three sets of rates are shown in the table.

COMPARISON OF METER RATES

		50 selected works with most of their services metered, less 10 per cent. of cost of services		146 works compiled by Mr. Biggs, less $1.25 per service per annum		Rate of $3 + 0.21 Dom. + 0.16 Inter. + 0.11 Mfg.	
Annual gallons	Quantity, cu. ft.	Amount of bill	Cents per 1000 gal.	Amount of bill	Cents per 1000 gal.	Amount of bill	Cents per 1000 gal.
10,000	1,330	$5.22	52.2	......	....	$5.10	51.0
30,000	4,000	7.05	23.5	$10.50	35.0	9.30	31.0
100,000	13,330	22.80	22.8	27.00	27.0	24.00	24.0
300,000	40,000	63.90	21.3	69.00	23.0	66.00	22.0
1,000,000	133,000	180.00	18.0	180.00	18.0	178.00	17.8
3,000,000	400,000	471.00	15.7	435.00	14.5	498.00	16.6
10,000,000	1,330,000	1,370.00	13.7	1,200.00	12.0	1,268.00	12.7

Electrolysis Mitigation

By EDWARD B. ROSA

Chief Physicist, U. S. Bureau of Standards

THIS paper summarizes the work which the U. S. Bureau of Standards has done during the last four years in studying the destructive effects of electric current on subsurface structures and prescribing remedies for the trouble. From the results of its investigations the bureau concludes that the proposal to fix by State law a general requirement as to voltage drop or current density in the rails is not logical, in view of the great variations in the damage which can result under different conditions with the same voltage drops.

One of the first methods resorted to as a means of preventing damage to buried gas and water pipes by electrolysis and soil corrosion consists in covering the surface of the pipes with a coating intended to insulate them from the surrounding earth. In many cases pipes have been so protected from soil corrosion but it is doubtful whether there is any instance on record where damage by electrolysis has been effectually prevented in this way if the voltage conditions were at all severe. On the contrary, there have been cases where such coatings have done actual harm, as they tend to fail in spots, and so permit the current to escape from the pipes at such places with a greater current density than otherwise, and so aggravate the local damage.

The paints, dips and wrappings tested by the Bureau of Standards were found to be of little or no value in protecting pipes from electrolysis when applied to the positive areas near power stations where the current is tending to leave the pipes. (Dr. Rosa explained that the bureau is now testing a product, known as bitumastic enamel, and that conclusions as to its worth have not yet been reached.) The bureau has come to the conclusion that money can be expended more profitably in other directions than in an attempt to insulate gas and water pipes from the earth.

INSULATING JOINTS

The bureau has found insulating joints of great value in reducing the current in pipe lines, and so reducing the corrosion caused by such current. Where the potential gradients are high the joints must of course not be placed too far apart, as in that case the potential difference at each joint would be sufficient to cause considerable joint electrolysis. Insulating joints should not be depended upon as the sole means of protection to pipes, but they are economically and mechanically practicable, and are a very important auxiliary means of protection, particularly in the case of gas pipes. They are less often used in water pipe lines.

TRACK AND PIPE DRAINAGE

Alternative methods of electrolysis mitigation are by the track drainage system and the pipe drainage system. The first of these methods is to be preferred if it can be carried out economically. It has, however, been thought by many to be prohibitive in cost and has been very little used in American cities. The pipe drainage system, on the contrary, has been strongly advocated and in one form or another much used. The investigations of the Bureau of Standards which have been extended over several years, have convinced its members that the pipe drainage system as a principal method of protection is not only complicated and expensive to install and maintain, but is in the long run not an adequate remedy for electrolysis troubles. On the other hand, the track drainage system when properly designed and installed is simpler, more effective and far less expensive than has been supposed.

COOPERATION DESIRABLE

Owners and managers of waterworks should cooperate with the gas and telephone companies and railways in studying the problem of electrolysis mitigation in an open-minded and progressive manner. Taking the matter into the courts is to be deplored. It is better to employ engineers to work together to solve the problem in a thorough and efficient manner than to employ experts to testify in court as to who is responsible or what are the damages. As the damage is cumulative from year to year and the rate increases as the traffic increases, there will be no better time than the present to take up the matter.

Water Main Leakage

By E. G. BRADBURY

Consulting Engineer, Columbus, Ohio

AS a unit for measuring leakage from water mains the writer prefers the number of gallons daily per mile for each inch of diameter, expressed as "gallons daily per inch-mile." "Gallons daily per foot of lead joint" is an equally rational unit—in fact, slightly more so—but is less convenient. The length of lead joint per inch-mile is about 120 ft.

By the method of open trench inspection it is possible to make a new system practically bottle tight. The measured leakage in 5½ mi. of 6 to 12-in. pipe laid and thus tested by the writer at Grandview Heights, a suburb of Columbus, Ohio, amounted to 2.3 gal. per mile daily, or 0.31 gal. per inch-mile.

TESTS AT AKRON

In designing the extensive improvements to the waterworks of Akron, Ohio, F. A. Barbour and the writer specified a maximum permissible leakage of 200 gal. per inch-mile daily—equivalent to about 1.6 gal. per foot of lead joint. The depth of lead specified is 2¼ in.

The results of the Akron leakage tests are given in the accompanying tables. The pressure ranged from 66 to 152 lb. per square inch.

Assuming the average diameter of pipe in a complete system to be 9 in., each 100 gal. daily per inch-mile saved or lost has a value of $3.28 per year for each mile of pipe at a production cost of $10 per million

TABLE 1—SUMMARIZED RESULT OF 86 TESTS OF PIPE LAID BY CONTRACT, AKRON.

Size, inches	Length, feet	Leakage gal. daily per inch-mile	Number of tests
4	717	23	1
6	31,066	66	34
8	6,882	42	6
10	5,123	81	5
12	9,704	102	8
16	8,792	135	11
20	8,389	69	10
24	3,358	69	3
30	14,445	82	8
	88,476	83.4	86

TABLE 2—SUMMARIZED RESULT OF 38 TESTS OF PIPE LAID BY SUPERINTENDENT OF WATERWORKS, AKRON

Size, inches	Length, feet	Leakage gal. daily per inch-mile	Number of tests
6	37,524	59	32
8	6,509	63	5
10	2,850	133	1
	46,883	61.7	38

gallons, or, capitalized at 7 per cent, is worth $46.86.

ALLOWABLE LEAKAGE

The writer proposes as a standard for allowable leakage in new cast-iron water pipe an average of 100 gal. per mile per inch of diameter for each complete contract or district, with a maximum limit of 200 gal. per mile per inch of diameter not to be exceeded in any single test. The recommendation is made, however, that open trench testing, with all joints visible, be specified, covering being done only by special order, and the allowable leakage clause being used only when it is entirely impracticable to keep the ground open.

Lessons from the Salem Fire

By FRANK A. McINNES
Boston Water Department,
And CLARENCE GOLDSMITH
Boston High Pressure System

BEFORE the recent disastrous fire at Salem, Mass., was subdued by the flank attack of twenty-seven engine companies, 253 acres were burned, involving the destruction of over 1700 buildings at a loss in excess of $14,000,000, all in the short period of 13 hours. The point of origin of the fire was adjacent to a 20-in. main where a normal pressure of 50 lb. obtained. The building in which the fire started, and those surrounding it, were of frame construction and mutually exposed, thus enabling the fire to spread with such rapidity that the adjoining buildings were almost immediately involved. Two of these were protected by automatic sprinklers.

Before the first hour had elapsed, ten engines were at work and a conservative estimate based on a careful study of lengths of hose lines, sizes of nozzles, and water pressures maintained at the engines, shows that at no time during this period was more than 2500 gal. of water per minute pumped from the distribution system, yet the recording pressure gage maintained by the water department registered a drop in pressure from its normal of 42 lb. to 20 lb. at the end of the hour. Fire engines arriving from nearby towns were handicapped by lack of water.

At the beginning of the fire the 20,000,000-gal. reservoir was practically full, the two 5,000,000-gal. pumping engines were in operation under a full head of steam. the 30 and 20-in. supply mains were in service and no breaks occurred in the street mains during the progress of the fire.

DISTRIBUTION SYSTEM TESTED

A test of the carrying capacity of the distribution system was made on Aug. 31. Four chucks were set on hydrants near the origin of the fire. These were opened, two discharging through three 2½-in. outlets and two through four 2½-in. outlets, and, in addition, a post hydrant in an adjacent alley was discharging through two 2½-in. outlets. The flow from each of the sixteen outlets was measured by Pitot tubes and showed a total of 8585 gal. per minute. The drop in pressure in the 20-in. main at the point where the test was made was observed on the pressure gage attached to a hydrant which was not discharging. This gage showed a pressure of 54 lb. prior to opening the hydrants, and while they were discharging the pressure was 22 lb. giving a drop of 32 lb. The quantity of water obtained shows an abundant supply at this point, an amount in excess of the combined capacity of the engines working at the end of the first hour. A draft from the mains equal to the previously estimated quantity pumped by the engines, namely, 2500 gal. per minute, would cause a local drop in pressure of less than 4 lb. On the date of the fire, the recording gage on Church street showed 42 lb. pressure when the first alarm was received. In 30 min. the pressure had dropped to 33 lb., and at the end of the hour to 20 lb.

SPRINKLER PIPES BREAK

From this record it is evident that a quantity of water approximately equal to the quantity obtained at the flow test was being withdrawn from the system and the principal object of this investigation is to account for this large rate of flow. One 8 and two 6-in. connections supplying the two sprinkler risks must bear the blame. The 8-in. connection from the 20-in. main was through 25 ft. of pipe to the sprinkler equipment in the Charles H. Keefe plant, and the two 6-in. connections supplying the sprinkler equipment in the Carr Leather Company's plant was fed through 200 ft. of 8-in. main connected to the 20-in. pipe. These buildings ignited immediately and a large number of sprinkler heads opened in a very short time but were powerless to check the fire, and the collapse of the buildings resulted in the breaking of the sprinkler pipes allowing the capacity of the three large connections to be wasted from the 20-in. main. To determine the actual effect of these three broken pipes they were opened shortly after the flow test above referred to was made with the following result:

A gage on a hydrant on the 20-in. main showed a normal pressure of 54 lb., and when the connections were open and flowing, a pressure of 31 lb., which, from the previous flow test, enabled the discharge from these pipes to be accurately determined at 7200 gal. per minute, a quantity of water in excess of the entire supply required for the fire protection of a city the size of Salem, according to the best modern practice. The Church street gage fell during this test from 46 to 33 lb. The effect of these broken connections is further evidenced by the record of this gage, which continued to drop during the fire until it registered 13 lb., at 3 p. m. when a supply at the rate of 8,000,000 gal. per day was delivered from the Peabody system without improving the pressure; at about 5 p. m. the heat abated so that these connections, together with a post hydrant, which had been discharging through two 2½-in. outlets, were closed and the pressure immediately rose to a little over 21 lb. in spite of the fact that many service pipes were broken at this time. It is evident that the broken connections had so depleted the supply of water that the fire department of metropolitan size was seriously crippled within one-half hour and rendered almost impotent as the fire progressed.

The lesson to be learned from the experience in Salem is that the existence of connections from a distribution system of such size that their failure destroys the pressure at the hydrant is a mistake that surely invites disaster to all waterworks systems and doubly so to those depending upon hydrant hose streams. All sprinkler systems should be provided with outside Siamese connections for the use of the fire department in order to check waste through breaks. The fire department would then have the supply under its control. Such a method of operation would preclude the possibility of a single large connection menacing the entire community. It must be borne in mind that the actual breaking of large connections is not necessary to bring disaster as the opening of too many sprinkler heads may be sufficient to cause serious results as might occur in a modern fireproof building which would not collapse and break the connections. The term "broken connection" in this paper means the destruction of the sprinkler system supplied through the connection. The three connections broken at the beginning of the Salem fire should prove an object lesson of equal force.

Automobile as Efficiency Agent in Waterworks

By GEORGE W. BATCHELDER
Water Commissioner, Worcester, Mass.

THE first automobile put in service for the Water Department of Worcester, Mass., was purchased in February, 1909. There are now eight machines in service but the equipment is not quite complete. The costs given cover in all cases every expense except for the operator and stable men. Depreciation is figured at 20 per cent and interest on investment at 4 per cent.

Car 1, a two-cylinder Buick equipped with a light express body, was put in service early in 1909. It was used as a meter and light repair machine and was available for emergency service at other times. After five years of good service the little machine was consigned to the junk pile to make room for a Ford car. During its service it carried the men to practically every meter job and to many repair and emergency jobs. The meter service trips alone numbered 4446 in 1909, 4040 in 1910, 4008 in 1911, 6094 in 1912 and 4752 in 1913. The average daily run of this machine was about 45 mi., equivalent to work which would have required three horses. The first cost of this machine was $1000. The operating cost, including all expenses, was $1048 a year.

Car 2, a four-cylinder Buick, model 17, was bought in 1910 for $1750. This car is used to transport engineers and office men 9 mi. from the city to Kendall reservoir, where for several years a dam and reservoir have been under construction. With the automobile the trip takes 25 min. as compared with 80 min. with horses. The cost of operating and maintaining this machine is $1200 per year.

Car 3, a Buick, model 21, was purchased originally as a touring car and later changed to a service car. It is now used for meters and light repairs, taking the place of the original truck 1. Its average run is 45 mi. daily. It costs to operate and maintain $1290 a year.

Car 4, a four-cylinder Pope-Hartford touring car, was purchased in 1913 at a cost of $2025. It is used by the water commissioner for inspection trips and by city council committees. Inspection trips of this nature cover an average of 35 mi. daily. It would take two horses to do this work and the commissioner would be in the saddle practically all day and there would be no time for office hours. This car costs $1280 per year to operate.

Car 5, a model 31 Pope-Hartford touring car chassis with a truck body, was bought in 1913 at a cost of $1800; the body made the total cost $1925. It is constructed with hangers outside the body so that several lengths of service pipe can be carried together with men and tools for installing services. This car makes it possible to get the work started early in the morning—long before it could be done if horses were used.

The daily average run is about 45 mi. The cost of installing service pipes has been reduced about 10 per cent since this automobile went into service. The total cost of operation and maintenance has been $1262 per year.

Car 6 is a Pope-Hartford 3-ton truck, equipped with extra-size dual rear wheels, making it equivalent to a 4-ton truck. This car has been loaded many times with 48-in. pipe weighing 8800 lb. or more and has been in service practically every working day since its delivery in March, 1913, with the exception of a period in March, 1914, when heavy snows made the operation of an automobile impracticable.

In 1912, the year before the car was purchased, the water department paid contractors for teaming the sum of $2700. In 1914, if the same rate prevailed per ton, the volume of business would make a bill of $8500 for the same kind of service. Deducting from that $1352 paid for teaming this year leaves the truck performing a service worth $7148.

COMPARISON WITH HORSES

An example of precise comparison between the work of horses in 1912 and the auto truck in 1913 is furnished by these figures: In 1912 seven pairs of horses hauled daily fourteen pieces of 48-in. pipe. In 1913 the one auto truck hauled daily fourteen pieces of 48-in. pipe. The cost of seven pairs of horses and drivers was $38.50 per day; the cost of the auto truck, operator and two helpers, with all expenses, interest, depreciation, etc., was $13.86 per day. The greatest day's work for the truck was 101¾ tons of 36-in. pipe hauled 40 mi.

Car 7, a Ford runabout, was used by the general foreman. Two horses had been required for this work. This car costs per year, all expenses, $291.

Car 8, a Velie 1500-lb. truck, is used for general light work. It handles with ease materials weighing more than a ton. This car has not been in service long enough to furnish any accurate figures of cost.

ROLLED IRON AND STEEL produced in Canada during 1913 amounted to 967,097 tons as compared with 861,224 tons in 1912, an increase of nearly 12.3 per cent, according to the Bureau of Statistics of the American Iron and Steel Institute.

Measurement of Flow in Open Channels

Improvements in the Screen Method Have Led to the Adoption of a Floating Apparatus with a Curved Screen

MEASURING the flow of water in open channels is generally done by current meters or Pitot tubes. Both of these methods, however, require long periods of time, and other devices have, therefore, been developed. One of these methods that has been developed in Europe is the screen method, which in addition to being quicker than the other also is considered more accurate. Its inventor is Prof. Eric Andersson of the University of Stockholm, Sweden. The method as first developed required a carefully aligned track on which a three-wheeled carriage ran. From this carriage the screen was suspended and hinged so that it could quickly be dropped into position. Several apparatuses of this kind have been installed, the most notable being at the testing flume of J. M. Voith, turbine builders at Heidenheim, Germany. At Notodden, Norway, there is also an installation of the same type.

This type of screen, however, is at this time to be considered antiquated and is almost entirely brought out of date by the improvements Professor Andersson has made on his method. The drawbacks of the method as originally devised were that a carefully aligned track was necessary, that the screen was vertical and thus when dropped had an angular movement, that the aluminum wheels and ball bearings of the carriage needed constant attention so as to insure against excessive friction losses and that wind pressure on the wheels increased the rolling friction.

IMPROVED APPARATUS

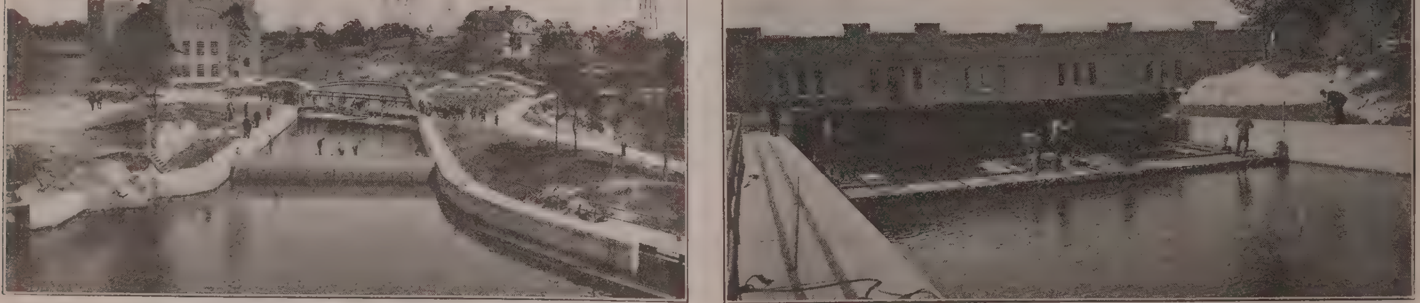
In 1910, when the large turbines at Trollhättan in Sweden were to be tested, Professor Andersson revised the design of his apparatus and eliminated many of the above-mentioned drawbacks. The screen was curved and pivoted below the water surface and the carriage replaced by a float. The apparatus is shown in the accompanying drawings and photographs. The float is supported on empty barrels and is made of 6 x 6-in. lumber. The screen is made of light channels, metric system, about 2½ in. high and 1.6 in. wide and weighing 4¾ lb. per linear foot, curved at a radius of 22 ft. 6 in. On both sides of these channels at frequent intervals are 4 x 1-in. boards spaced in pairs and separated by small wooden blocks. Lateral stiffness was obtained by stretching ¼-in. cables diagonally in the panels. On this frame was fastened a cover of tarpaulin so as to obtain water-tightness. Four radial 6 x 3-in. timbers, two on each side, served to connect this screen with the submerged pivots on the float. Between the lower pair of these timbers a cross bracing of ¼-in. cable was made so as to prevent deformation. The whole apparatus was built in a way similar to that of a Tainter gate. At the bottom of the screen there was a loose, hinged part so as to secure a water seal against the bottom of the canal. The design of the float is apparent in the accompanying drawing.

As the canal was 50 ft. wide and 29 ft. 6 in. deep it was deemed wise to build the float and its screen in two parts, each 25 ft. wide, and connect them side by side when in use. This arrangement facilitated the construction and the handling of the device when not used for measurements.

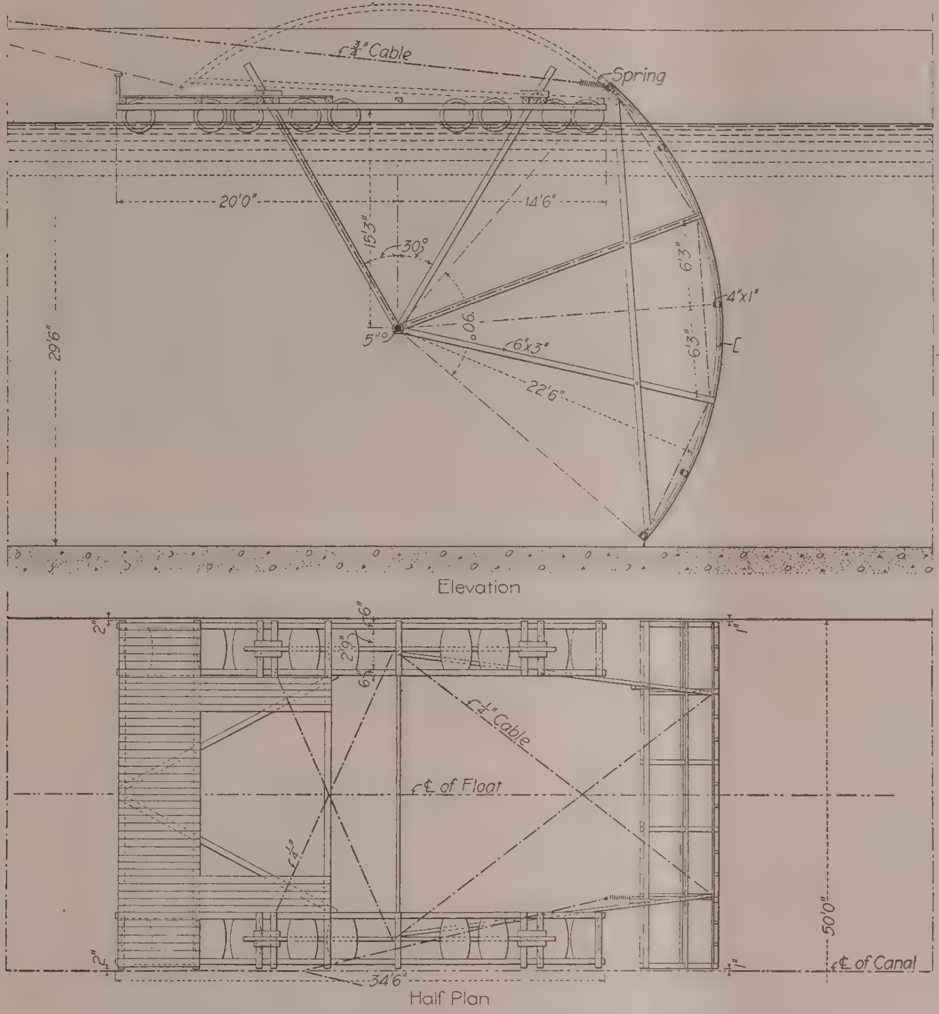
METHOD OF RECORDING TIME

The rectangular portion of the concrete canal is about 115 ft. and at its upstream end it is crossed by a highway bridge. On this bridge the recording apparatus was placed and connected with the screen by a ¾-in. wire rope, which was branched and thus connected with both halves of the float. The recording drum was driven by the pull on this cable at a speed one-twentieth the speed of the screen, while a pencil actuated by clockwork marked every 0.01 min. The speed was also measured on a scale 65 ft. long laid out on the concrete work of the canal bank. Two men, each provided with a chronograph, recorded the time required by the screen to move a certain distance. In comparing the results of the two methods it was found that the chronographic method was less accurate than the diagram apparatus and its records were, therefore, not used. As the discharge in the canal was used to feed the turbine under test only the measured velocities were low, varying from 0.3241 to 0.8807 ft. per second and the corresponding discharges from 508.9036 to 1375.5582 sec.-ft. Afterward the leakage through the gates on the spillway in the forebay and through the closed headgates was measured and found to be 1.7658 sec.-ft.

These tests were made June 24 to 26, 1910, under the supervision of Professor Andersson and E. Andren, at which time four main turbines had been installed. During May 10 to 13, 1913, when two more units had been installed, the screen was again used with very much the same results as above described. It was found, however, that the leakage had increased 60



VIEWS OF SCREEN APPARATUS USED IN MEASURING FLOW FOR LARGE TURBINES AT TROLLHÄTTAN, SWEDEN



DETAILS OF FLOAT AND CURVED SCREEN FOR MEASURING FLOW

per cent., while the area of the headgates had been increased less than 50 per cent. These latter tests were made under the supervision of A. H. Lindfors, Arvid Lindstrom and Anders Rosborg.

Performance of Seagoing Suction Dredge "New Orleans"

Notes Taken from Paper by Major Edward H. Schulz, Corps of Engineers, U. S. A., in "Professional Memoirs"

PERFORMANCE figures for the United States seagoing suction dredge "New Orleans" during the years 1912 and 1913 are recorded by Major Edward H. Schulz, Corps of Engineers, U. S. A., in the September-October "Professional Memoirs."

The dredge, as described by Major Schulz, is 315 ft. long, 50 ft. wide and 26 ft. deep. It is of the suction-hopper type, with twin screws and twin rudders. The hull is of steel and has a well in the stern in which the dredge arm works. The dredge is capable of working to a depth of 50 ft. below the light-water line. The length of hopper is 93¾ ft.

The dredging equipment consists of two 26-in. centrifugal pumps, with pipe connections to the dredge arm at the trunnions and to the deck pipes for overhead and hopper discharge. The hoppers have internal piping for pumping out. The two 26-in. suction pipes along the dredge arm terminate in a common dredge head, which may be likened to a large hoe, from 10 to 20 ft. wide, which sinks into the bottom and receives the material to be dredged.

The suction head is of the Frühling type, and is at the end of the drag arm, which is hinged and suspended from the stern of the vessel. The original suction head is made of segments of three widths and can be made 10, 16 2/3 or 20 ft. wide. The pressure water (200 lb. per square inch) can be used as jets on the cutting edge to loosen hard material or as mixing water inside the head when the mud is thick enough to choke up the suction to the pumps. The opening in the suction head is controlled by portable baffle plates.

Two other suction heads have been made. One of these, which is similar to the type of drag generally used on the other hopper dredges, with the bottom built like a grating, has not as yet been used. The other is a modified Frühling head, in which the side and bottom projections have been eliminated and the bottom has been rounded. This head seems to be more efficient than the original where the material is hard clay and sand, or clay with 2 or 3 ft. of sand on top. In favorable weather the dredge is able to drag this head over the bottom and scrape the material from the top.

The accompanying table gives figures as to the quantities handled during the fiscal years 1912 and 1913, and the costs thereof. For the fiscal year 1914, up to April 1, 1914, at which time 1,060,969 cu. yd. had been removed, the unit operating cost is the still lower figure of 6.07 cents per cubic yard.

Performance of Dredge "New Orleans" during Fiscal Years 1912 and 1913

	1912	1913
Location	Southwest Pass	Southwest Pass
Character of material	Sand and mud	Sand, mud and silt
Average distance to dump	2 mi.	3 mi.
Quantity dredged during year	186,515 cu. yd.*	1,280,054 cu. yd.
Total number of loads	187	934
Number of loads per day, working	3.9	4.28
Average quantity per load	997.4 cu. yd.	1,371 cu. yd.
Average quantity per day	3,885.7 cu. yd.	5,871 cu. yd.
Average quantity per hour	399.7 cu. yd.	786.75 cu. yd.
Percentage of time pumping	29.50	18.58
Percentage of time going to and from dump	14.30	8.23
Percentage time from other causes, including time at night when not working	56.20	77.19†
Total hours of all service in year	1,056	8,760
Operating cost for year	$21,009.06	$82,085.49
Average cost per hour at work	$29.51	$23.35
Number of days on which any dredging was done	48	218
Average number of working hours per day	14 hr. 40 min.	16 hr. 7 min
Average time to dredge one load	1 hr. 39 min.	1 hr. 45 min
Average time to dump	13 min.	12 min.
Average time going to and returning from dump	48 min.	46 min.
Total cost during year	$23,199.06	$92,730.22
Cost per cubic yard, without repairs	$0.111	$0.0685
Cost per cubic yard with ordinary repairs	$0.124	$0.0688
Total cost per cubic yard, with extraordinary repairs	$0.124	$0.0724
Fuel, tons	1,411.74	6,753.64
Cost per ton	$4	$3.95
Fuel, per cubic yard dredged	15.12 lb.	10.55 lb.
Total mileage of dredge	1,152	4,813
Total cost per yard-mile	$0.062	$0.0241

*Dredge began working April 12, 1912.
†Includes nights when the dredge had a single crew.

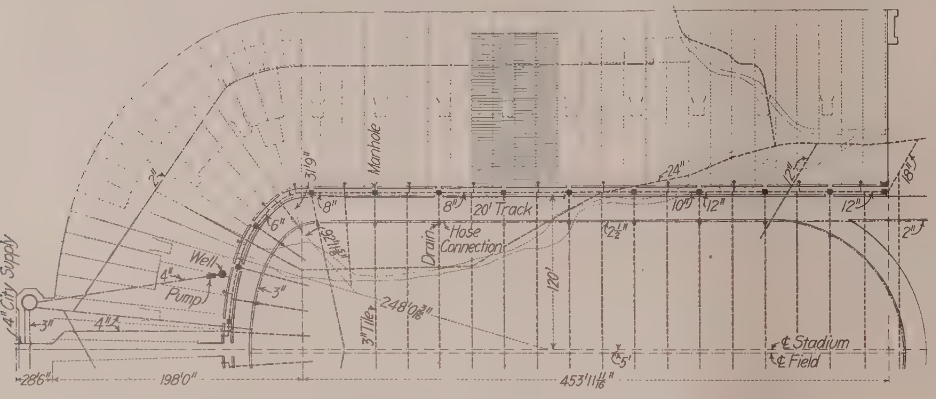
Cotton Records of Water Quality

TO city councilmen and water commissioners tabulated statistics of the physical, chemical and bacteriological qualities of a water supply convey little meaning. At the Boston convention of the New England Waterworks Association last week Prof. George C. Whipple of Harvard University described a method of picturing the quality of water on cotton disks, the object being to present to the layman a record which he cannot fail to understand. The scheme consists in filling an ordinary quart milk bottle with the water to be tested and attaching to its top a metal cap in which there is a pocket for holding a thin disk of cotton about an inch in diameter. The bottle is inverted and its contents allowed to strain through the cotton, which intercepts sediment and algæ. The disk is then removed, dried and pasted in a book. The discoloration of the cotton is an index of the quality of the water. The metal cap is fitted with a rubber bulb and tube so that air can be forced into the bottle to assist in expelling the water. The sheets upon which the pieces of cotton are pasted are ruled into thirty-one squares so that a month's record of the quality of the water and its daily variations are strikingly set forth.

Princeton Athletic Stadium

U-Shaped Structure of Reinforced-Concrete with a Seating Capacity of 41,000, Involving Many Novel Features of Design

THE Palmer Memorial Stadium at Princeton University is rapidly nearing completion and will be ready for the Yale-Princeton football game in November. The stadium will accommodate 41,000 spectators and provide standing room on the promenade for several thousand more. It is built primarily for the annual football games, but a ¼-mi. running oval and a 220-yd. straightaway have also been incorporated in the layout. In designing the stadium the governing idea was to locate the seats so that the spectators should be as near as possible to the gridiron and have unobstructed lines of sight. These requirements led to the adoption of a plan in the form of a U. Both legs were made straight and were to be connected by a semicircular section, as in the Harvard stadium. It was found, however, that the seats near the center of this section would be too far away from the gridiron and the semicircular shape was, therefore, abandoned, and an elliptical curve substituted, as shown in the accompanying plan. The main entrance is located in the center of the curved end.



PART PLAN OF STADIUM, SHOWING DRAINAGE AND WATER SUPPLY

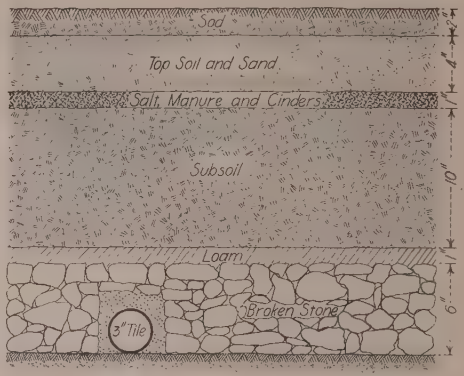
Natural Conditions

Five sites were considered in locating the stadium, each of which was carefully studied, the objectives being to avoid marring the appearance of the university buildings, to hold to a minimum amount of rock excavation (because of the cost) and to give a maximum amount of fill for grading around the structure. Two sites were abandoned because they did not provide sufficient parking space for automobiles; another was so close to the other buildings that the stadium would have dwarfed them had it been erected there; the fourth was on the side of the gully and required too much rock excavation. The fifth site, near Carnegie Lake, was found to have all the required natural conditions in respect to rock excavation, fill, parking space, etc.

In locating the stadium the plan was drawn on tracing cloth and moved about on a contour map of the property which showed all the sites. The final location places the structure with its open end toward the lake, thus giving the spectators a beautiful view of the surrounding country. The longitudinal axis of the structure points a little to the west of north, so that in the middle of November, when the big games are played, the sun's rays will fall at right angles across the gridiron, and, therefore, as little as possible in the players' eyes.

The stadium is a reinforced-concrete structure consisting mainly of a series of buttressed piers carrying an outer wall with large arched openings; transverse bents spaced 16 ft. 10 in. apart supporting the seat tiers, and a field wall separating the seats from the field. At the top of the structure is a 12-ft. promenade, and inside the exterior line of piers is a 20-ft. concourse, from which ramps lead to the seats. On the inside, or seating end, these ramps terminate at the same elevation, while at the other end they vary, depending upon the slope of the concourse, the ramp nearest the main entrance being at El. 140 and those nearest to the ends at El. 130. To avoid too steep a slope the ramps near the ends have steps as shown in one of the accompanying illustrations. There are twenty-six ramps in all, of which nine are located in either wing and placed 50½ ft. on centers, and eight are evenly spaced in the elliptical portion. The length of these ramps is 56 ft. 2 in., 10 ft. wide for a distance of 43 ft. and 8 ft. wide for the remainder, where the ramp passes through the opening to the seats. Reinforced-concrete beams between the columns serve to support the ramps, the railings of which serve as girders to support the floor. The opening to the seats is enclosed on three sides by a concrete wall 3 ft. 2 in. high and 4 in. thick, to prevent accidents and to divert rain water.

The design of the bents supporting the deck is shown in the accompanying cross-section. On the elliptical part, where the bents diverge in plan, their number is reduced at each concentric line of columns. This arrangement is apparent on the plan. Between the bents in several places diagonal struts have been provided to act as sway bracing and to take up lateral stresses due to wind pressure.



SUBSURFACE OF PLAYING FIELD

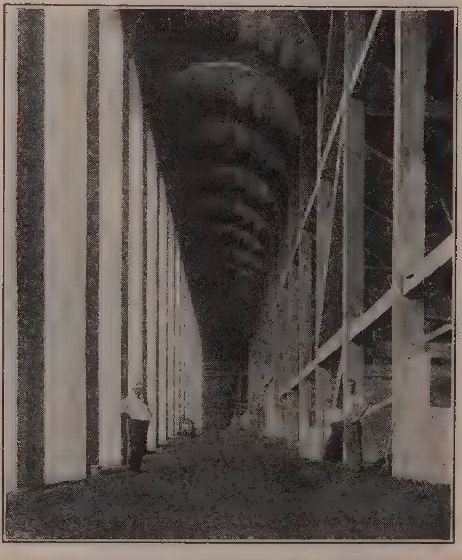
Seat Tiers

Reinforced-concrete steps spanning the distance between the supporting bents constitute the seat tiers, of which there are forty-eight. To give the spectators as unobstructed a view as possible the tiers are bowled. As it would have involved complications in construction had all the treads and risers been different, this curve was approximated by its three tangents, so that, from the field, the first twenty treads are 2 ft. 7 in. wide and the first twenty-one risers 15 in. high. On the next tangent the treads, fifteen in number, are 2 ft. 6 in., while the risers are increased to 16 in. The last tangent has twelve treads 2 ft. 5 in. wide, with risers still farther increased to 17 in. The promenade at the top is separated from the seats by a low concrete wall, forming a wind shield. Inside the field wall a 3-ft. walk has been provided. Four steps located in front of each ramp lead from this walk to the field. The seat tiers are connected by steps 3 ft. wide having a 1-ft. tread and riser equal to half the rise of the tier. There are, therefore, 100 steps from the field to the top of the structure.

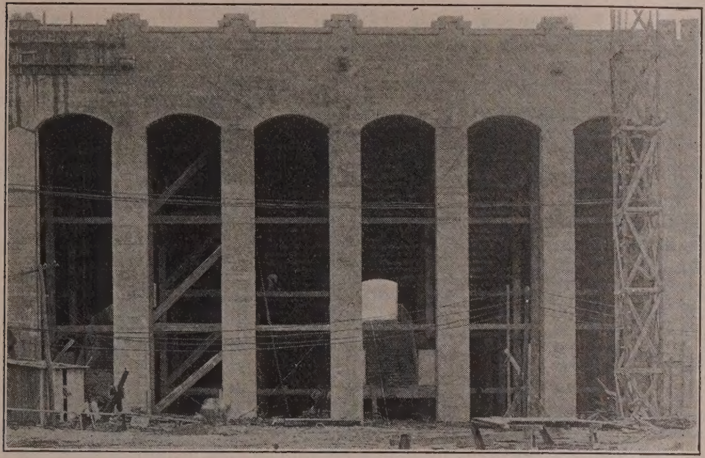
To make comfortable seats the concrete treads will be fitted with planks, slightly overhanging the edge. They will be of cypress painted to match the concrete. These wooden seats will be fastened to the concrete with expansion bolts.

Main Entrance

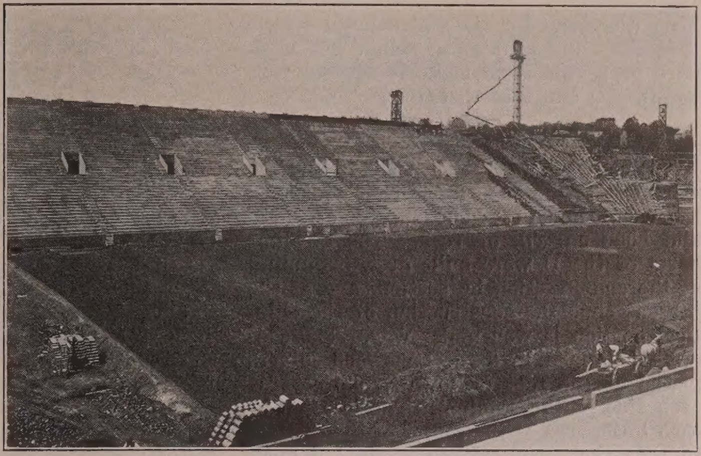
On the center line of the stadium is the main entrance opening on the concourse. From this the players' entrance leads to the field. Dressing and locker rooms and baths will be located in a track house near this end of the stadium. Two towers flanking the great archway of the entrance give a distinguished architectural effect to the structure, which has been designed to conform to the Princeton buildings in the collegiate Gothic style. The players' entrance follows the natural grade until the slope of the seats makes it necessary to excavate



CONCOURSE BENEATH STADIUM



PART ELEVATION OF EXTERIOR OF STADIUM



FACING VIEW OF ONE SIDE FROM OPEN END

to get sufficient headroom. The entrance is provided with concrete fences and its field portal is treated like that of the ramps. Ticket offices will be located on the ground floor of the towers at the main entrance. The mezzanine floors will be used for storage of tools required to keep the stadium and the field in condition and the top floors will contain water tanks.

PLAYING FIELD

Besides the gridiron the field will have a ¼-mi. elliptical running track 15 ft. wide, and a 220-yd. straightaway 20 ft. wide. These different widths offset the long axis of the football field 5 ft. from the axis of the stadium. As the straight portion of the stadium is only 454 ft. long it was necessary to extend the straightaway outside the stadium, as in the Harvard stadium, which could readily be done because of the open end. The width inside the field walls is 250 ft. Around the field outside the running track is a 5-ft. walk fenced off by a concrete wall 3 ft. high, with openings opposite every other ramp. A low concrete curb separates the football field from the track.

The design of the gridiron was also an important point on which specialists had to be consulted. In accordance with their advice the field was excavated 2 ft. below the finished grade. In building up the gridiron the first course consisted of a 6-in. layer of broken rock in which 3-in. tile drains are placed 25 ft. apart to carry off the water. Then come 1 in. of loam, 10 in. of subsoil, 1 in. of land salt, manure and cinders, 4 in. of top soil mixed with sand and finally 2 in. of sod. The land salt was mixed with the manure and cinders so as to kill worms and prevent the field from being undermined. The center of the gridiron is 1 ft. higher than the longitudinal sides so that the slope is about 1 per cent. This was done so as to facilitate the drainage of the surface.

SANITARY PROVISIONS AND PLUMBING

Eight toilet rooms, four for women and four for men, will be located under the seat slope of the stadium as shown in one of the drawings. The water supply is obtained by electric pumping from an artesian well sunk beneath the stadium, and the pressure is obtained from tanks located on the top floor of the towers. These tanks are 10 ft. in diameter and 12 ft. high, interconnected by a 3-in. equalizing pipe. One of them is provided with a tank switch connected with a solenoid motor starter at the pump so that the operation is automatic. Overflow pipes are installed so that no damage would befall the towers should the switch fail to operate.

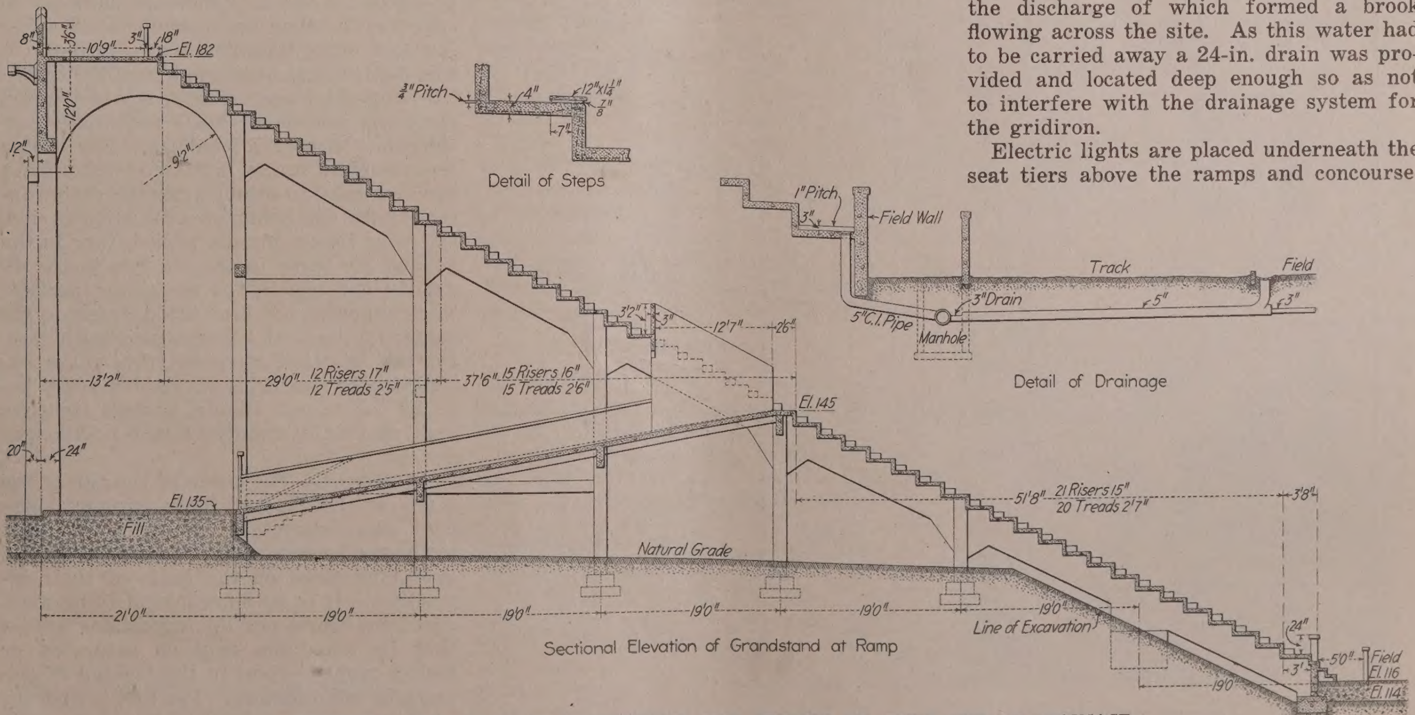
Should the water supply in the well be insufficient at any time to fill the requirement, a 4-in. pipe connects the tanks with the water-supply system of the university buildings. This pipe rises above the tank and its discharge is regulated by a float valve. Another 4-in. branch connects directly to the mains around the field.

From the tanks a 4-in. pipe leads to the field, with 2-in. branches to the toilet rooms. The field is encircled by a pipe located inside the running track, on which nine 1¼-in. hose connections are available. In locating these connections it was assumed that the sprinkling radius of one hose would be 100 ft. For the part of the straightaway projecting beyond the stadium the pipe has a 200-ft. 2-in. branch with hose connections 90 ft. apart.

The drainage from the seat tiers is collected inside the field wall, where the 3-ft. walk has been built with a slope toward the drains. A concrete gutter between the field and the running track conveys the surface drainage to risers on the 3-in. tile drains. Manholes on the main sewers have been located as shown on the plan.

At the upper end of the field was a spring, the discharge of which formed a brook flowing across the site. As this water had to be carried away a 24-in. drain was provided and located deep enough so as not to interfere with the drainage system for the gridiron.

Electric lights are placed underneath the seat tiers above the ramps and concourse.



SECTIONAL ELEVATION OF GRANDSTAND AND DETAILS OF STEPS AND OF DRAINAGE

This was done for the convenience of the spectators, in case a game should last until dark or a rainstorm make it necessary to use the structure as a shelter.

CONSTRUCTION

The contract was let on April 15 and the work was begun at once. The job involved the excavation of 80,000 cu. yd. of earth and 5000 cu. yd. of rock. The straight parts of the U were built first, beginning at the ends, section by section, and at the present time the construction of the elliptical portion is well under way. The concrete is mixed in 2-yd. Lakewood mixers placed at the foot of towers, one set for each side of the stadium. The location of each tower was at the center of the section, so that the concrete was spouted a horizontal distance of 260 ft. These towers with their mixers were later on, when the straight portions had been finished, moved to the elliptical part of the stadium. Wooden forms are used throughout.

Square twisted bars of various sizes constitute the reinforcement, of which there will be about 450 tons. The concrete, which is mixed very wet because of the long distance it is spouted, is proportioned 1:2:4. For the foundations the concrete was mixed by hand in the proportion of 1:3:5 and placed by wheelbarrows. It is estimated that about 20,000 bbl. of cement will be used. Electric motive power is used for all the construction machinery. No expansion joints have been provided, as the reinforcement is designed to take up temperature stresses. The field was laid out, graded and sodded by the middle of August.

The stadium, which will cost $300,000, was donated to Princeton University by Edgar Palmer, a graduate of the class of 1903, and is to be known as the Palmer Memorial Stadium in memory of his father, the late Stephen S. Palmer. The structure was designed by H. J. Hardenbergh, architect, of New York City. Purdy & Henderson, consulting engineers, designed the reinforced-concrete details. The George A. Fuller Company is the contractor.

Kansas City Rain-Runoff Diagram

Curves Developed for Sewer Designing, Combining Study of Local Conditions with Methods and Values Used Elsewhere

By ROBERT S. BEARD
Department of Engineering, Board of Public Works, Kansas City, Mo.

THE rain-runoff diagram developed by the writer for sewer designing in Kansas City, Missouri, is a local application of the results of a study of the methods of and values used by Emil Kuichling in Rochester, N. Y., Rudolph Hering and C. E. Gregory in New York City, C. E. Grunsky in San Francisco, W. W. Horner in St. Louis and others. The reasonable flow of storm water for which to design any system of sewers is very difficult to determine.

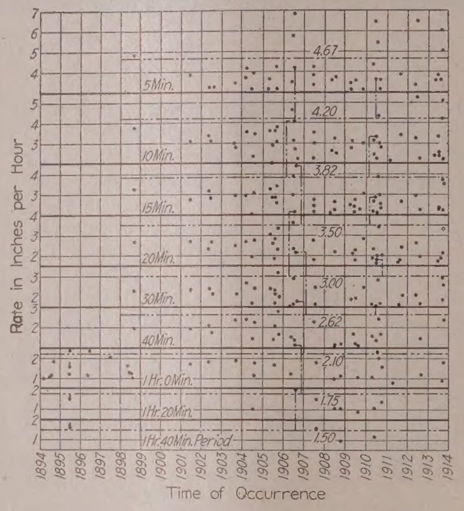


FIG. 1—EXCESSIVE RATES OF RAINFALL AT KANSAS CITY

First of all, the design intensity of rain is established by excluding certain abnormally heavy rains in the past history of the city, the uncared for runoff from which will, in the designer's judgment, damage the district less than the cost of the additional sewer capacity. The exact relation between the varying physical condition of the watershed and the maximum rate of storm flow in the sewers can only be determined by actual measurement in each particular case. In addition to this, it is good practice to design the sewers to take care of conditions twenty years or more in the future, and the actual increase in population and change in the character of the watershed is bound to vary considerably from the most careful estimate. Nevertheless, a detailed survey of the various factors entering into the problem in the light of what data is available is most likely to result in a rational basis for design.

The Kansas City diagram has been constructed in the following manner. Any point on any curve of the diagram is the result of the simultaneous solution of four different curves representing the following factors:

1. The design intensity of rain for each concentration period.
2. The average time from the beginning of the storm to the center of the period of maximum downpour on the watershed.
3. The ratio of runoff to intensity of rain for the different types of areas at different periods of excessive rains.
4. The relation between the percentage of impervious area in the watershed and the density of population.

A fifth independent factor in the problem is the inlet concentration period.

DERIVATION OF CURVES

Rain Curve.—The rain curve, the equation of which is $I = 210/(t + 40)$, has been determined by an analysis of the official rain records of P. Connor, the local weather forecaster. Flooding the short-period sewers is normally of little consequence, as the capacity of the street is generally sufficient to care for the small amounts of excess water involved while they flow an extra block or two down grade before entering the sewer. Flooding the longer sewers, however, often results in serious washouts and causes considerable property damage. For these reasons eight rains in sixteen years have been excluded in establishing the design intensity for the 5-min. concentration period, six rains in the 10-min. period, four in the 15 and 20, three in the 30, two in the 40 and 60 and one in the remaining periods. The rain curve has been fitted closely to the values of the next lower rain in each case. For all practical purposes this curve excludes only two rains in sixteen years between the 15 and 40-min. periods inclusive and one rain in twenty years for all longer periods.

Age Curve.—The curve of the age of the storm at the time of the maximum downpour was determined by taking the ages of the ten heaviest rains in each period and averaging them on the basis of their intensities. It is no more logical to pyramid all of the worst possible conditions here—that is, maximum rain on saturated or frozen ground—than in the loading of columns in tall buildings. The fact is that our maximum rains generally follow a dry spell,

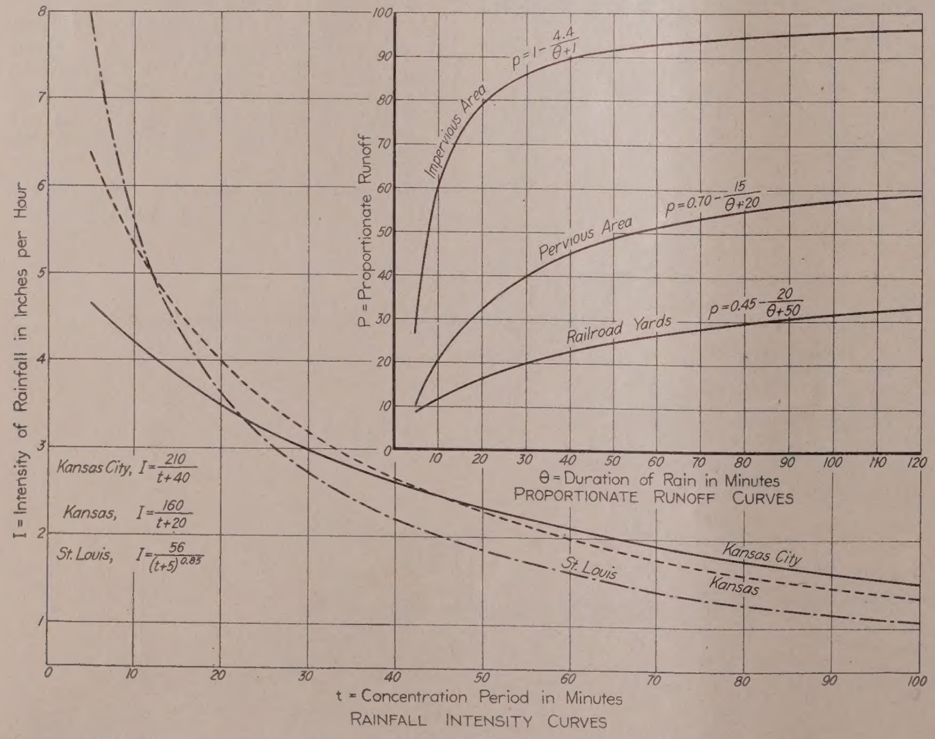


FIG. 2—CURVES OF RAINFALL INTENSITY AND PROPORTIONATE RUNOFF

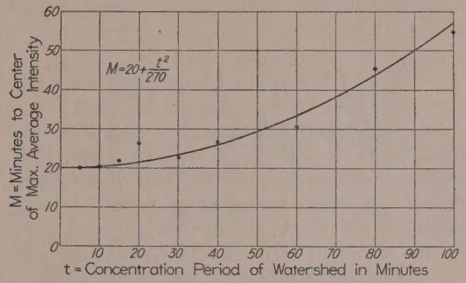


FIG. 3—AGE OF RAIN AT CENTER OF MAXIMUM DOWNPOUR

and never occur when the ground is frozen.

Runoff Curves.—All three of these curves, expressing the ratios of the maximum rates of flow in the sewers to the corresponding intensities of excessive rains are essentially judgment curves, based largely on a study of available runoff records and somewhat on local experience. The upper two curves give values approximately the same as the values adopted by Mr. Horner for use in St. Louis, but are used in this case on a somewhat different basis. The majority of published sewer gagings give somewhat lower rates of runoff, but from our experience with the flooding of old sewers it has become evident that these rates are approximately correct for Kansas City. The grades are very uneven here, but will average between 2 and 3 per cent.

Urban-Development Curve.—The curve expressing the relation between the density of population and the ratio of impervious area in the watershed was worked out by Mr. Kuichling from a detailed study and analysis in typical districts in Rochester of the proportions of the watersheds which were covered by roofs, sidewalks, roadways and other wholly or partly impervious areas.

Several independent studies made here in Kansas City were found to agree fairly well with this curve. For greater densities than eighty people per acre the impervious area increases very little with increases in the population. In Kansas City the typical block is 5 acres, and there are five and two-tenths people to the house. It follows that for all practical purposes the number of houses to the block equals the population per acre. A quick rough census of the sewer district may be taken in this manner as a basis for estimating the density of population at the future period for which the designer is planning to provide.

Inlet concentration is estimated by various authorities to require from 3 to 15 min. Mr. Horner concluded from his observations that it takes the water from street, sidewalks and roofs from 2 to 5 min. with grades of from ½ to 5 per cent on improved streets to reach the sewer, and that it takes the water even in heavy rains from 10 to 20 min. to flow 100 ft. over grass.

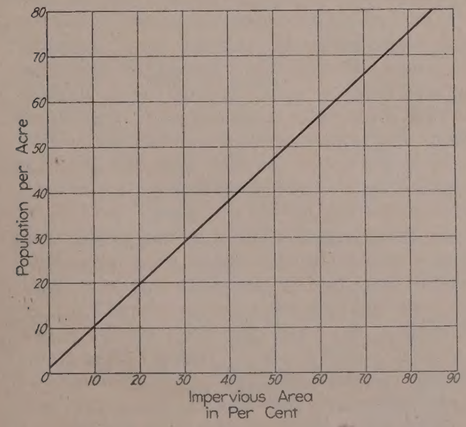


FIG. 4—RELATION OF IMPERVIOUS AREA TO POPULATION

DERIVATION OF DIAGRAMS

For the most impervious areas the writer has assumed that it takes 3½ min. for gutter concentration and 3½ min. in the gutters at 2½ ft. per second to the inlets, making a total of 7 min. for the inlet-concentration period. For the more pervious areas the concentration period has been arbitrarily increased 1 min. for each decrease of ten in the population per acre.

The construction of the diagram will be made evident in determining the rate of runoff for a 15-min. sewer where the density of population is thirty people per acre.

From the urban-development curve, Fig. 4, 0.314 of the acre is impervious; from the intensity curve, Fig. 2, the value of I is 3.82 in., and from the age curve, Fig. 3, this intensity occurs 20.8 min. from the beginning of the storm, at which time, from the proportionate runoff curves, Fig. 2, the rate of runoff from impervious areas is 0.790 of the intensity of the rain. Then, on the basis of $Q = AIp$, the impervious runoff equals $0.314 \times 3.82 \times 0.790 = 0.948$. Similarly, the pervious runoff equals $0.686 \times 3.82 \times 0.328 = 0.860$, and the total runoff in cubic feet per second per acre = 1.808.

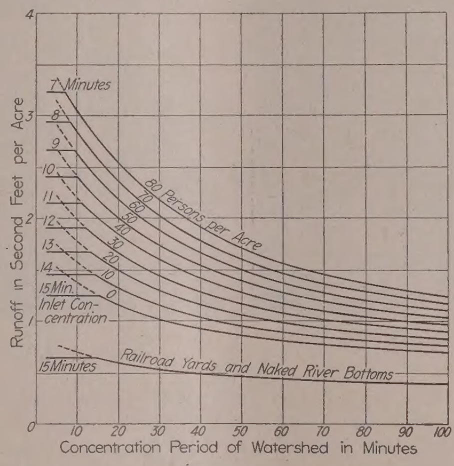


FIG. 5—RAIN-RUNOFF DIAGRAMS DERIVED FROM PRECEDING CURVES

The steep grades of Kansas City result in very short concentration periods. The O. K. Creek sewer (See the Engineering Record of Nov. 2, 1912, page 480), which is approximately 4 mi. long and is one of our main sewers, has a concentration period of 38 min. The range of these diagrams is about twice that required for our purposes.

CONCLUSIONS

In designing sewers it is customary to start at the upper end of each lateral with the inlet-concentration period, and to work down the sewer, increasing the time according to the distances and velocities between inlets. At each junction the larger contributing period is carried on downstream. This method furnishes a rational basis for reducing the rate of rain runoff as the sewer increases in length, and the small increase in the amount of labor required in designing the sewers cannot be considered as a factor influencing the value of such a method because of the much larger costs of construction involved.

Concrete Pavements Laid Against Car Tracks

A ½-Cubic Yard Mixer Using Washed Beach Gravel Mixes Concrete for Street in Duluth

CONCRETE pavements on Lake Avenue, Duluth, Minn., are being laid next to the rails of the single car track traversing Minnesota Point, a narrow strip of sand and gravel upon which Duluth Harbor depends for protection. It seems to have been formed by the combined action of northeast storms on Lake Superior and on the St. Louis River. In the vicinity of the pavement the whole formation is composed of quite flat beach gravel free from sand. To make it at all possible for teams, foreign material has been hauled in. Although it is hard, on account of the flatness of the gravel, a two-course pavement was adopted.

Each side of the rails the paved section is 12½ ft. wide, 8 in. deep at the end of the ties and 6 in. at the concrete curb. The top 2 in. is of 1 part Universal Portland cement, 1 part sand and 1 part crushed trap rock. In the 1:3:5 mixture in the bottom course the gravel on the road excavated from the grading is screened and washed by fire hose in the street ahead of the concrete outfit. This reduces hauling to a minimum, and in many cases the small stock piles are near enough to wheel gravel to the mixer. Longitudinal joints of ¾ in. are left next the curb to be filled with pitch. The rail is painted with pitch and Baker expansion joints filled with ⅜ in. of Elastite are placed every 33 ft. Between the bottom and top courses the pavement is reinforced with the American Steel & Wire Company's No. 28 triangle mesh.

Curbs are 6 in. wide on top and 8 in. at the base. Because of excessive contraction due to low winter temperature, they are cut up into 5-ft. sections by ¼-in. steel plates, which also act as spacers for the 2-in. forms. Later pitch is poured into these joints.

This is the first season the city has attempted to do its own paving. A ½-yd. Smith mixer is rented at $3 per day, but as it is not a paver it is set with the charging hopper resting on the rail and the discharging end pointing toward the curb. Men wheeling concrete circle round the mixer on a runway. About three sections are paved from one setting. From thirty-five to forty men lay about 275 sq. yd. per day. This gang includes men washing and screening gravel and building the curb with hand-mixed concrete ahead of the paving gang.

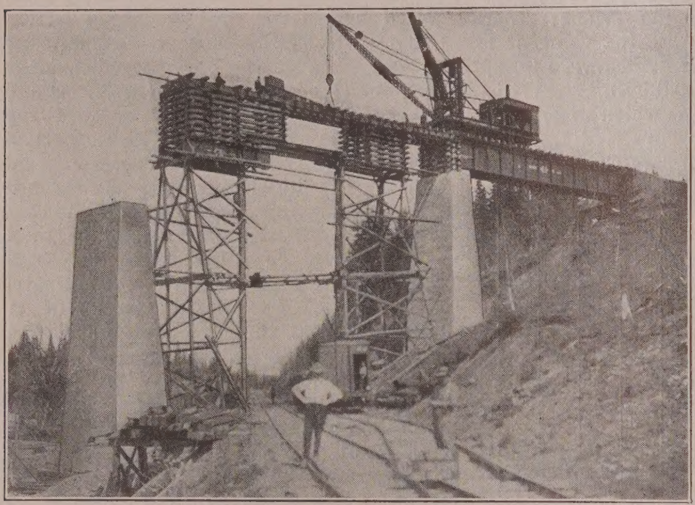
All work is done by city forces under the direction of John Wilson, city engineer.

CONCRETE PAVEMENT WORK AT DULUTH

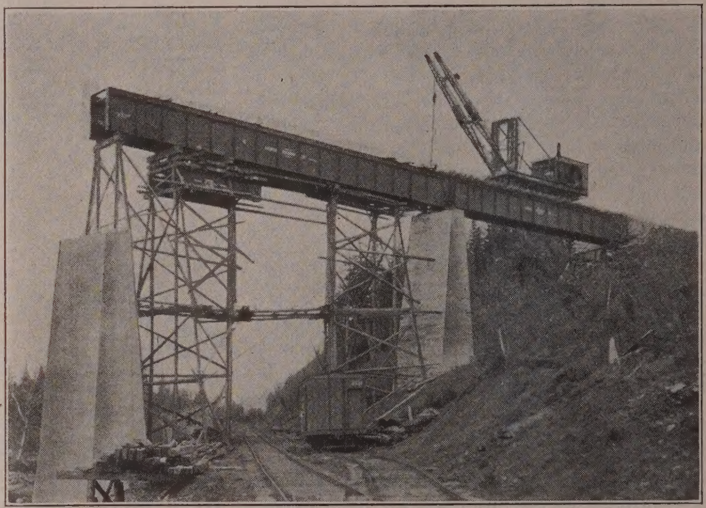
Novel Method of Erection of Tobique Bridge

Long Plate-Girder Span on Transcontinental Railway in Canada Was Erected on Falsework Towers by a Derrick Car

THE Tobique bridge of the Transcontinental Railway of Canada has at one end a 100-ft. span with two deck-plate girders weighing about 32 tons each, which were erected on falsework towers and cribbing. The adjacent end spans, 80 ft. long, were erected in the usual way by a two-boom derrick car at grade. The car advanced on this span and with the steel booms extended by wooden spars, built in advance a wooden falsework tower as high as the top of the first pier. Cribwork was then constructed on top of the tower, extending it up to the level of the top flange of the end girder, and supporting wooden stringers on which the traveler advanced to erect a second falsework tower 28 ft. in the clear from the first tower. Cribwork was similarly built on top of this tower, and both cribs were united by heavy wooden stringers on which a track was laid, enabling the girders to be brought out from the end of the bridge and seated on the cribwork.



FALSEWORK TOWERS AND CRIBBING TO SUPPORT SPAN



DECK PLATE-GIRDER SPAN JACKED DOWN TO GRADE

LOWERING THE GIRDERS

The forward ends of the girders overhung the tower about 15 ft. with their bearings over the center line of the pier. This pier, being intended to receive also a 140-ft. deck truss span 30 ft. deep, was not built high enough to take the bearings of the girder span. The latter was eventually placed on a steel transverse bent and pin-connected to the end shoe of the truss span, and as this bent could not be built at the time the girders were erected their ends were temporarily supported on a wooden pony bent seated on top of the pier. The span was jacked up enough to release the cribbing and then lowered to permanent position on its bearings on top of the shore pier and on the pony bent on the second pier. The bottom flanges were also wedged to bearing on the cribbing, and the latter, together with the falsework, were retained to give the structure stability until the adjacent truss span was erected and the pony bent replaced by the permanent steel bents.

R. F. Uniacke was the bridge engineer. The bridge was fabricated and erected by the Canada Foundry Company, of Toronto.

Depreciation in Carrying Capacity of Pipes

Formula for Cast-Iron Mains Based on Studies Made for the Consolidated Water Company of Utica, N. Y.

A STUDY of the depreciation in carrying capacity of cast-iron pipe has been made by Robert E. Horton, consulting engineer, of Albany, N. Y., resulting in the development of a new formula by which the increase of friction with the age may be estimated. It was assumed that the coefficient of roughness increases by a constant annual percentage, and if n is the coefficient for new pipe and n_1 that for a pipe N years old.

$$n_1 = n\,(1 + PN) \qquad (1)$$

The coefficient P should have such a value that in a very old pipe, say 100 years old, n will not exceed 0.016 (this coefficient is based on actual experiments). The coefficient P is therefore 0.006, thus allowing for an increase in the coefficient of roughness of 0.6 of 1 per cent per year.

Let D = original diameter of a pipe in feet; D_1, its diameter at the end of N years, and K, thickness of the annual ring of incrustation in feet. Then

$$D_1 = D - 2KN \qquad (2)$$

Equations (1) and (2) express the coefficient of roughness and the diameter of the pipe in terms of age. Applying these values of D_1 and n_1 in the formula for discharge, the ratio of the discharge, Q_1, at the end of N years to the original discharge, Q, is obtained. Or

$$\frac{Q_1}{Q} = \frac{\text{Old carrying capacity}}{\text{New carrying capacity}}$$

The Kutter-Chezy formula may be written

$$v = (B/n)\,\sqrt{RS} \qquad (3)$$

where (B/n) replaces c of the Kutter formula; n = coefficient of roughness; v, velocity in feet per second; R, hydraulic radius; S, hydraulic slope (h/l); h, friction head in feet, and l, length of pipe in feet. For the new pipe the area is $\pi D^2/4$ and $R = D/4$, so that

$$Q = (B/n)\,(\pi D^2/4)\,\sqrt{(D/4)\,(h/l)} \qquad (4)$$

and consequently

$$\frac{Q_1}{Q} = \frac{(D_1^2/n_1)\,\sqrt{D_1}}{(D^2/n)\,\sqrt{D}} = \frac{D_1^{5/2}n}{D^{5/2}n_1} \qquad (5)$$

Substituting the values of n_1 and D_1 found above,

$$\frac{Q_1}{Q} = \left(\frac{D - 2KN}{D}\right)^{5/2} \frac{1}{1 + PN} \qquad (6)$$

In order to determine the value of the coefficients K and P, it was assumed that in the average main at the end of 30 years there has been deposited a layer of sediment ⅛ in. thick at the bottom and 1/16 in. at the top. The effective cross-section, however, is reduced by a somewhat greater amount because of slack water or eddies between the projecting irregularities or tubercles, so that the effective radius is decreased by an amount somewhere between the average thickness of the sediment and its maximum thickness. Accordingly, the effective diameter of the pipe was reduced by one-third more than the assumed average thickness of the sediment, making the reduction in diameter equivalent to ¼ in., or 0.02083 ft. in 30 years, or 0.000694 ft. per year. Thus

$$2K = 0.0007 \text{ (in round figures).}$$

The formula will therefore read

$$\frac{Q_1}{Q} = \left(\frac{D - 0.0007N}{D}\right)^{5/2} \frac{1}{1 + 0.006N} \qquad (7)$$

In arriving at the coefficients for K and P the local conditions at Utica, N. Y., served as the basis. It is believed, however, that the factor covering variation in n is a fair one to apply to all cases. The increment of incrustations may be greater or less in other localities.

TESTING WATER MAINS was the subject of an extended discussion following the paper which E. G. Bradbury, consulting engineer, of Columbus, presented last week at the Boston convention of the New England Waterworks Association. It was found that leakage tests were sometimes unreliable if the main was filled and tested on the same day. The disturbing factor was thought to be air in the pipe. No trouble was experienced when the main was filled and tested after the lapse of a day. Emphasis was laid on the importance of making all leakage tests before backfilling the trench so that the pipe need not be uncovered for repairs. W. C. Hawley cited a case where excessive leakage developed when the lead joints of a pipe line had been hurriedly calked while hot in order to have the line ready for a test which was to be viewed by the mayor and an official party.